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Sky and TELESCOPE

London Planetarium

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Sky and TELESCOPE

CHARLES A. FEDERER, JR., *Editor*
JOSEPH ASHBROOK, *Technical Editor*

Vol. XVII, No. 9 — JULY, 1958

CONTENTS

COVER: Located on Marylebone Road not far from the Baker Street station of London's underground railway, the newly opened London Planetarium adjoins Madame Tussaud's museum of famous figures exhibited in wax. In this recent view, the waxworks building is at the right, and the planetarium stands on the site of a motion-picture house that was destroyed during an air raid in World War II. (See page 440.)

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IAU Moscow Meeting

HUNDREDS of astronomers from all parts of the world will gather in Moscow for the 10th general assembly of the International Astronomical Union on August 11th to 20th. The delegates will be guests of the U. S. S. R. Academy of Sciences while in Russia. The sessions will be held mainly at Lomonosov University.

The latest such general assembly was held in 1955 at Dublin, and the next one after the Moscow assembly, in 1961, will probably be in the United States. These gatherings are of great value to astronomy, giving researchers from widely scattered countries opportunity to exchange their results, discuss current problems, and coordinate future work.

A concise listing of some of the liveliest areas in today's astronomy is given by the topics for the several symposia and joint-commission discussions: the Hertzsprung-Russell diagram (involving star clusters, associations, and stellar evolution); the earth's rotation and atomic time standards; astronomical observations from artificial satellites, rockets, and balloons; Cepheid variable stars; the formation of chemical elements in stars; and solar flares and corpuscular streams.

Of especial importance to everyone attending are the meetings of about 40 IAU commissions, each devoted to a particular field, such as variable stars, minor planets, standard wave lengths, or stellar spectra. The names, fields of interest, and memberships of committees are subject to review and change, reflecting the changing emphasis as new fields of astronomical study arise. The Moscow program contains many recommendations of this kind, including formation of a new commission on magnetohydrodynamics and the physics of ionized gases, and one on solar eclipses.

So full is the program for the eight working days at Moscow that many sessions are scheduled to run until 11 p.m. But on Sunday, August 17th, the astronomers will have a day for sightseeing and excursions. Before and after the official meeting days, some of the visitors will travel to Poulkovo Observatory near Leningrad, Simeis Observatory in the Crimea, Samarkand in Central Asia, and other places.

Astronomers of some 40 countries belong to the IAU. Its president is French; there are vice-presidents from Belgium, England, France, Germany, Poland, and Russia; the secretary is Dutch.

Many of the IAU delegates are also planning to attend the July 30-August 6 Paris symposium on radio astronomy, and the meeting in Brussels during early September on statistical problems in astronomy. It will be an eventful summer for the astronomical traveler.

A technician is making some minor adjustments on the new Zeiss projection instrument in the London Planetarium. The skyline of the city is silhouetted in plywood against the lower rim of the chamber's perforated sheet-aluminum dome. The projector parts can be identified in the drawing on page 442. All illustrations with this article are courtesy the London Planetarium, Ltd.

London's New Planetarium

HENRY C. KING

London Planetarium

THE LONDON PLANETARIUM, first in the British Commonwealth, opened its doors to the public on March 20th with the program, "The Earth Is Our Spaceship," a demonstration of planetary motions. During the first four weeks, more than 75,000 persons attended the planetarium, which seats 550 and presents an average of six public showings daily.

Architects' plans were begun as early as 1936, but the planetarium project was temporarily halted by the second world war. During the blitz, a 1,000-pound bomb fell on Madame Tussaud's cinema, unexpectedly clearing the site for the "Theater of the Skies," which was later built here as an extension of the famous waxworks. The location was just large enough to accommodate a 67-foot projection dome — the size recommended by the Zeiss company, manufacturers of the projector.

The location had a serious disadvantage, for the underground railway runs below one corner of the lot, and each passing train sets up surface vibrations. George Watt, the architect, countered this by making the building of great weight, supported by 12 concrete columns which rest in turn on 48 piles driven more than 50 feet below the ground. This practical design solved the vibration problem completely.

The white-painted inner surface of the dome is 16-gauge sheet aluminum, with 20 regularly spaced 0.08-inch perforations per square inch, making more than 20 million in all. Their purpose is acoustical, to prevent reverberation which would otherwise drown out the narrator's voice.

To keep the noises of busy London from penetrating into the planetarium chamber, the inner dome is contained within a multi-layered outer protective dome. First there is a blanket of sound-absorbing material, next a three-inch-thick concrete shell separated from another similar one by a three-inch air space filled with fiberglass. The second concrete shell is covered with cork and over this tarred felt is laid; the outermost layer in this sandwich is copper sheeting. Tests confirm the acoustical excellence of this system, which also acts as a good heat insulator.

Air conditioning of the dome's interior serves another purpose besides the comfort of the audience. At any time some 5,000 individual beams of light pass from the projector to the inner surface of the dome, and to preserve the illusion of reality these must be invisible. The tiny particles of dust that pervade the atmosphere of London would reflect and scatter light. Therefore the air is filtered and can be changed as often as eight times an hour. At the maximum rate, the pressure inside the dome is about two pounds per square inch higher than that outside, a most effective means of keeping out city dust.

An unusual feature of the building's design allows the public to see the pro-

LONDON PLANETARIUM PRESENTATIONS

Weekdays	**11:00 a.m., 12:15, 3:00, 5:30*, 6:45*, 8:00 p.m.***
Saturdays	**11:00 a.m., 12:15, 3:00*, 4:15*, 5:30*, 6:45*, 8:00 p.m.***
Sundays	**3:00*, 5:30*, 6:45*, 8:00 p.m.***
Bank Holidays:	**9:45, 11:00 a.m., 12:15, 1:45, 3:00*, 4:15*, 5:30*, 6:45*, 8:00 p.m.***

* Denotes presentation for which seats may be booked in advance.

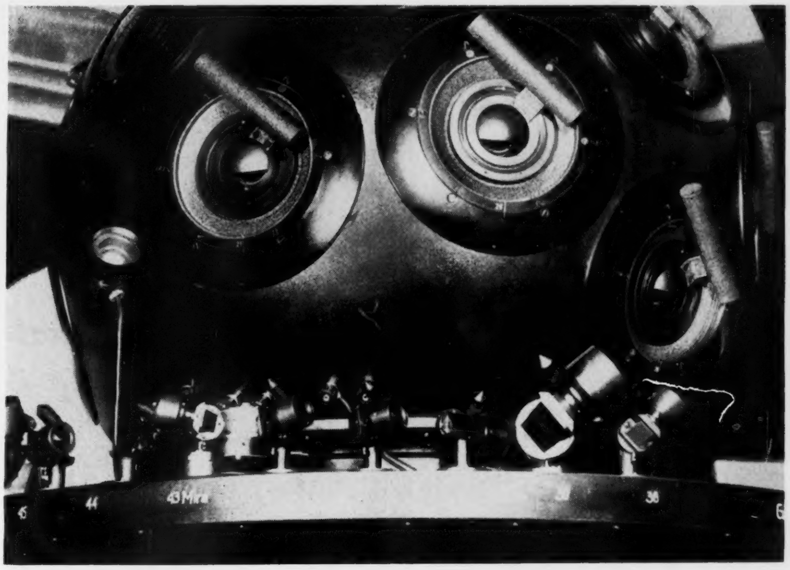
PRICES OF ADMISSION

Morning (weekdays)	**11:00 a.m., 12:15 p.m.**	**2/-**
Afternoon (weekdays)	**3:00 p.m.**	**3/-**
Evening (weekdays)	**5:30, 6:45, 8:00 p.m.**	**4/-**
All Saturday, Sunday, and Bank Holiday presentations		**4/-**

jector when it is not in use. At such times it is lowered by a special elevator to the ground floor, where it may be seen inside a protective glass cage by people in the foyer and by passersby on Marylebone Road. At the touch of a switch, four electric motors raise the platform and projector noiselessly 20 feet into the auditorium. (The projector of the Buhl Planetarium in Pittsburgh, Pennsylvania, also may be lowered and raised by an elevator mechanism.)

The projector itself is the 33rd to leave the Zeiss works, now at Oberkochen in West Germany. Its central assembly is a dumbbell 13½ feet long and weighing more than two tons, containing about 29,000 individual parts, of which nearly 200 are optical projectors. In the open-lattice cylinder that joins the two large star globes of the dumbbell are projectors for the sun, moon, and five naked-eye planets. Together the two star globes produce about 8,900 stars down to magnitude 6.5, each of the correct relative brightness and properly located in its constellation.

Costing almost $200,000, the London instrument has many improvements over earlier models. For 42 1st- and 2nd-magnitude stars there are individual projectors, mounted on the ruff around each star globe. The images show the characteristic reddish colors for Aldebaran, Betelgeuse, and Antares, and the yellowish hue of Arcturus.

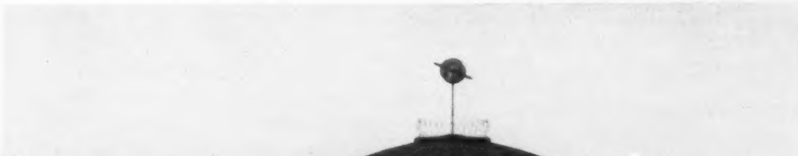


This closeup shows the large collar at the base of one star globe; the two collars carry separate projectors for 42 of the brightest stars. The resulting images are more brilliant and smaller than if projected in the same way as fainter stars. Three special motor-driven projectors reproduce the naturally changing brightness of the variables Algol, Mira, and Delta Cephei. The collars also carry new, smaller Milky Way projectors.

In early Zeiss instruments, the star plates for the globes were hand-perforated sheets of copper foil, with 65 different sizes of holes. Although the result was quite satisfactory, the plates did not prove sufficiently durable, and for newer projectors another method was adopted. On large sheets of blackened metal were pasted disks of white paper of the proper sizes and relative positions to represent naked-eye stars. (In placing the disks, allowance had to be made for the projectors not being in the center of the dome, but about 5½ feet from it.) The finished sheets were then photographed and the negatives used to prepare photoengraved plates. There are 16 such plates fitted into each of the 30-inch globes of the great dumbbell. Every plate has its own f/4.5 Zeiss Tessar optical projection system and aspherical condenser lens, all grouped around a central 1,000-watt bulb.

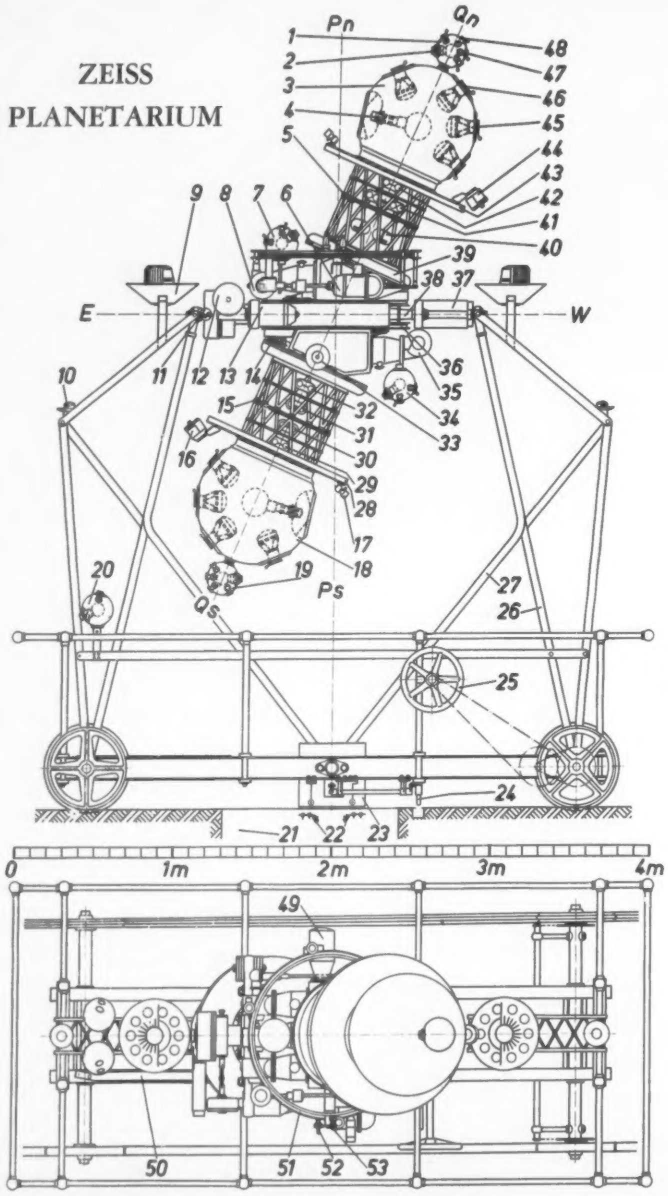
As in other Zeiss instruments, to make the planetarium stars dim naturally as they approach the skyline, which is 10 feet above the floor, mechanical blinkers swing over the projection lenses like artificial eyelids, slowly reducing the light. This device also prevents those star images that happen to be below the skyline from appearing on the floor or flashing across the eyes of the spectators.

Also mounted near the star globes are the Milky Way projectors. Large drawings of the Milky Way were prepared, using stippling to indicate the gradations of brightness, which were then photographed. The films were placed inside the two drum-shaped projectors, providing a most realistic effect. Special projectors depict solar eclipses, the zodiacal light, the gegenschein or counterglow, and



For many months people passing Madame Tussaud's waxworks were puzzled by the dome-shaped structure being erected nearby. The planetarium, pictured here in a late stage of construction (see also the front cover), is the first of its kind in the British Commonwealth.

ZEISS PLANETARIUM



(1 and 19) *Two globes for constellation names and precession dial.*
(2) *Projectors, 15 per globe.*
(3 and 18) *Two fixed-star globes, each with 16 projectors (45).*
(4) *1000-watt lamp.*
(5 and 15) *Two planetary frameworks for Saturn (42), Sun with aureole (41), Moon (40), Mercury (32), Venus (31), Mars (30), and Jupiter (29).*
(6) *Projector for year counter.*
(7 and 34) *Two globes with 6 projectors each for the equatorial grid reference system, ecliptic, and the two celestial pole markers.*
(8) *Three motors for the annual movement.*
(9) *Two dome illuminators providing white and blue light.*
(10) *Two horizon illuminators for morning and evening sky glow.*
(11) *Polar altitude reader.*
(13) *Polar altitude variation motor.*
(16 and 44) *Two Milky Way projectors.*
(17) *45 Special projectors for the 42 brightest fixed stars and the 3 variable stars Algol, Mira Ceti, and Delta Cephei.*
(20) *Two spheres, each with 2 projectors, for the Celestial meridian.*
(33) *Mechanical precession counter.*
(35) *Two motors for the diurnal movement.*
(46) *Mechanical eye-lids, 16 per globe.*
(48) *Mechanical eye-lids, 15 per globe.*
(49) *Motor for the precessional movement.*
(51) *Equipment for demonstrating the Mean Sun and the nautical triangle.*
(52) *Vertical circle projector.*
(53) *Hour circle projector.*

A view into the interior of one of the massive star projector globes, which give the Zeiss instrument its characteristic dumbbell appearance. The light of a 1,000-watt electric lamp is picked up by the aspheric lenses and projected through photoengraved sheets, were openings of different sizes produce stars of a wide range of brightness. There are 16 projection units in each star ball, making 32 to cover the entire sky.

comets. The planetarium lecturer can show the celestial equator, the ecliptic, and other reference lines on the artificial sky.

Each of the five bright planets has its own projection assembly, with gearing so precise that the planets' motions are accurate, to the limit of naked-eye observation, for many centuries into the past or future. The planet images have characteristic disks: Mars is red, Jupiter appears with belts, and Saturn has rings. Mercury and Venus are distinguishable by their relative sizes. Twin projectors are used, so that the latticework cannot extinguish the image as the projectors turn.

The various motions of the earth — from its daily rotation to the 26,000-year

precessional motion — can be demonstrated within a few minutes by the instrument.

The London Planetarium also has a full complement of the new Zeiss auxiliary devices, to simulate meteor showers and aurorae, and to show the solar system as seen from beyond the orbit of Saturn. For teaching constellations the narrator can project individual constellation figures by the flick of a switch, and also the names of the star groups.

With these facilities, the new London Planetarium is well equipped to bring the wonders of the heavens to the population of one of the world's largest cities, mostly cut off from the sky of nature by lights and smoke.

The speaker's console of the London installation has an impressive array of buttons, switches, and rheostat controls, permitting the lecturer to obtain the motions and special effects needed for each demonstration. In the upper left is the projection orrery, which reproduces a miniature solar system on the planetarium dome. In center background of this picture is the special projector for constellation figures.

GETTING ACQUAINTED WITH ASTRONOMY

THINGS TO OBSERVE IN THE SKY — III, *by Edward G. Oravec*

THE SUN

Observing the sun can afford the amateur real enjoyment. With proper precautions to avoid damage to his eyes from the sun's light and heat, the observer can count sunspots and study the granulation of the sun's visible surface. With somewhat specialized instrumentation, such as a polarizing monochromator, he can see hydrogen prominences at the edge of the solar disk.

Even the smallest telescope can be used to view sunspots by projection onto a white card. The observer should have diagrams of the solar disk on which to record the positions of the spots. If this is done from day to day, a clear picture can be obtained of the nature of the sun's rotation. If a spot is large, or there is a group of spots, the time of its disappearance around the sun's limb should be noted and a vigil kept for its return at the opposite limb, a little less than two weeks later. Sunspots occasionally are large enough to be seen with the naked eye, but care should be taken to look for them only with very dense filters (through which nothing but the sun can be seen).

Systematic sunspot observations by American amateurs are organized by the Solar Division of the AAVSO. Observers who wish to contribute to the program, and to have their sunspot counts included in the computation of the American sunspot numbers, are first required to undergo a trial period to test and develop their observing abilities.

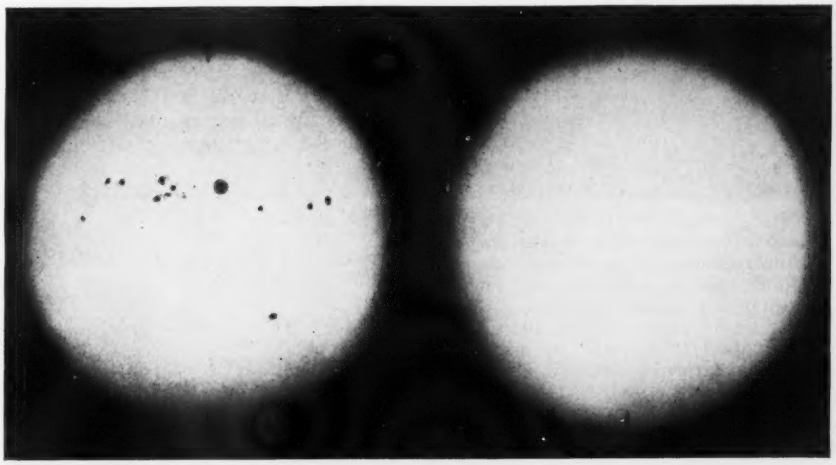
A solar eclipse, when the moon comes between the earth and the sun and partially or totally hides it, is an outstanding event. In the latter case, when the eclipse is total, the scene has been described as nature's most magnificent spectacle. Total eclipses are rare at any one spot on earth, yet amateurs often have opportunity to travel to the narrow path of totality to observe and photograph the event. Thousands of persons journeyed to see the eclipse of June 30, 1954, when the moon's shadow crossed centrally over Minneapolis and St. Paul, in Minnesota. A sunrise eclipse is scheduled for eastern Massachusetts in October, 1959.

THE MOON

Most amateurs are acquainted with the elementary facts concerning the moon: its general surface markings, its phases, and its motion across the sky. Optical aid is required to become better acquainted; also a lunar map is needed as a guide in locating the various formations.

The appearance of the moon's craters, mountains, and plains varies greatly with the phases. The study of any particular object is best made when the sunlight strikes it at a low angle, bringing details into bold relief. Near full moon, when our line of sight is in the same direction as the sun's rays, we cannot see the shadows on the moon, and its surface appears flat and almost featureless, but the difference in brightness between the dark maria ("seas") and the mountainous regions is very noticeable.

Although the moon takes about 27 days to revolve around the earth, the period of its phases is 29½ days; this is the average time from one new moon to the next. But there are only two or three days each month when it is impossible to see the moon because of its proximity to the glare of the sun. For several days before and after new moon, earthshine may be seen — the moon's dark part faintly illuminated by sunlight reflected from the earth. The phenomenon is easily detected with the naked eye, and in binoculars many features in the dark area are fairly conspicuous. The bluish color of earthshine is more apparent if the sunlit crescent is masked from view. The brightness



The sun at times of maximum (left) and minimum spottedness. Note the fading of the sun's disk toward its edge; this is called "limb darkening." The spike-like marks at the top and bottom of each image indicate a north-south line. Mount Wilson Observatory photograph.

The partial lunar eclipse of May 3, 1958, photographed from the Mojave Desert and sent by Gregory Smith. The exposure was 1/60 second for the full moon before eclipse (top), 1/60 second for the penumbral phase (middle), and 1/15 second for the maximum umbral darkening (bottom). His report is on page 464.

of earthshine varies considerably, but it may sometimes be seen in binoculars even when the moon is at more than the quarter phase.

Being nearer the earth than any other permanent celestial body, the moon sometimes passes between us and a planet or star. Such an event is called a lunar occultation; it is an especially interesting sight when a very bright object disappears behind the dark edge of the moon. An occultation of a star gives us a precise measure of the moon's position in the sky, if the instant of occultation is exactly recorded. The timing of occultations has been an important task for amateurs in the past, but their work is being largely superseded by special methods developed by professional astronomers.

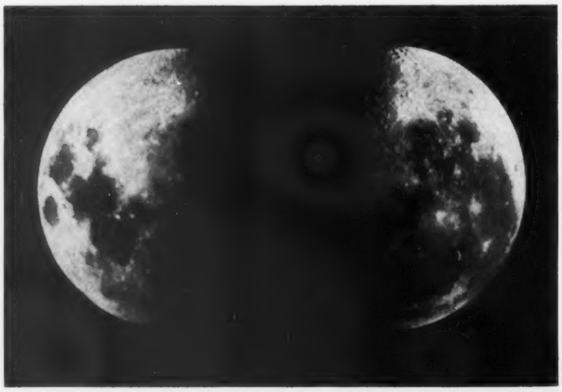
Even with the naked eye, a lunar eclipse is a most interesting sight. Low-power glasses or small telescopes do much, however, to heighten appreciation of the color changes during a total eclipse of the moon. From any one observing location, an eclipse will be visible every year or two, on the average. Eclipses of the moon show such marked differences among themselves that careful descriptions by amateur astronomers may have scientific value. The visibility of the lunar features when they are immersed in the shadow varies strikingly from eclipse to eclipse, and there have been a few "black" eclipses, when the shadow was so dark that no details could be seen within it.

The Planets

One of the major fields of particular interest to the amateur astronomer is planetary observing. With only limited optical aid, a surprising amount of information may be gained by the serious student. For naked-eye work, the variations in brightness, the motions among the constellations, and the periods of visibility of each individual planet reveal many significant facts. With binoculars, the motions of Uranus and Neptune may be observed, as well as a few of the minor planets or asteroids. With telescopes, the disks of the nearer planets are easily seen, revealing the rotations of some of them, their changes of phase with orbital position, and markings on their visible surfaces. The satellites of Jupiter and Saturn are especially attractive in amateur instruments.

Mercury is the planet nearest the sun, and the fastest-moving one. Despite its reputation as the elusive planet, it is not

These pictures by amateur astronomer Herb Bassow show the moon at two important phases: nine days after new (left) and 20 days old. Near the terminator (sunrise or sunset line) much detail can be seen because of the long shadows cast by the sun's grazing rays. Far from the terminator, the moon appears almost featureless, except for the dark lunar "seas."



The atmosphere of Venus causes the cusps of its crescent phase to extend more than halfway around the disk. Drawing from "Splendour of the Heavens," London.

too difficult an object for naked-eye observation, although it is rarely visible except in twilight. At its brightest, it is nearly a match for Sirius, the brightest star in the heavens. In tropical regions, where twilight is shorter, Mercury can be seen occasionally in a dark sky. Under favorable conditions during late winter and early spring, in the Northern Hemisphere, Mercury may be visible to the naked eye as little as seven days from inferior conjunction, and even a day or two closer in binoculars. However, the best times to look for the planet are a week before evening elongation or a week after morning elongation (see page 481).

Venus appears to move much more slowly than Mercury, taking 19 months instead of four for a complete cycle of its appearances. Ordinarily outshining all the planets, and brighter than any celestial object except the sun and the moon, Venus presents a beautiful sight in the sky. After superior conjunction with the sun, the planet requires about four months to reach greatest eastern elongation, when it may set four hours after the sun. It dominates the western evening sky and approaches the earth so close that its apparent disk grows to about one minute of arc in diameter; the crescent phase before inferior conjunction

(*Continued on page 448*)

Launching an Aerobee-Hi rocket from Holloman Air Force Base, at Alamogordo, New Mexico, in September, 1957. The solid-fuel booster drops off soon after the flight begins, and the rocket's motor takes over. At the left in the foreground is a helicopter used for servicing the missile during the last minutes before firing.

Far-Ultraviolet Radiation of the Night Sky

OTTO STRUVE, *Leuschner Observatory, University of California*

DURING the past 10 years, there has been a rapid disappearance of the artificial line of demarcation that has separated astronomy from physics for the last two or three centuries. In earlier times, Galileo and Newton were physicists as well as astronomers, and their contemporaries called them "natural philosophers" without attempting to distinguish between astronomers and physicists.

But nearly 300 years ago the demands of navigation resulted in the creation of the first two great national observatories, at Greenwich and Paris, and soon afterward other countries organized observatories on the same pattern. The principal purpose of these institutions was to find a practical and accurate method of determining geographical longitude.

John Flamsteed, the first Astronomer Royal of England, realized that the solution of this problem required new star catalogues and lunar tables, based on better observations than any existing at the time. There is no doubt that this practical aim — curtailing the basic desire of every scientist to explore the nature of the universe regardless of useful applications — led to the formation of an almost impenetrable barrier between astronomers and physicists. And the situation was not improved when the problems of navigation were followed by those of geodesy and surveying.

Even though the practical aims of the great observatories began to recede into the background during the 19th century, astronomers found that their observations of precise positions of stars and planets were opening up new problems. These involved the variation of latitude, irregularities in the earth's rotation, perturbations of planetary orbits, and proper motions of stars. But most of these problems were of little interest to physicists.

The development of astrophysics during the past 75 years initiated a need for astronomers to remove the barrier. In America, George Ellery Hale clearly recognized this, and throughout his life emphasized that astronomy is an integral part of physics and that the solution of astrophysical problems requires the closest co-operation between astronomers and physicists. First at Yerkes Observatory and later at Mount Wilson, he organized physical laboratories where spectroscopic and similar investigations of astrophysical interest could be carried out.

Hale's initiative has been copied at other institutions. For example, one of the most successful astrophysical organizations in the world today is the Institut d'Astrophysique at Liege, Belgium, where experimental physicists are studying molecules known or suspected to be present in the outer parts of stars, in comets, and in planetary atmospheres.

All these efforts have been dwarfed since the second world war by the explosive rise of interest in astronomical problems by many physicists. An excellent illustration is the exploration at ultraviolet wave lengths of the background radiation of the night sky. Observations of this airglow at visible wave lengths were described by Franklin E. Roach and Pauline M. Jamnick in the February issue (page 164). In the present article, we are concerned with the airglow in the far ultraviolet, chiefly in the vicinity of the Lyman-alpha line of hydrogen at 1216 angstroms.

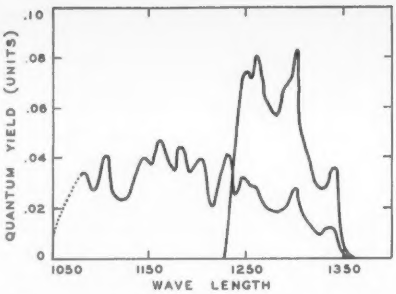
Only 12 years ago, the short-wave limit of astronomical observation was 2850 angstroms; all shorter wave lengths are completely absorbed by molecules such as ozone, oxygen, and nitrogen in the lower layers of the earth's atmosphere. But since 1946 many spectroscopic and radiometric observations have been made with instruments carried above these layers by rockets, to levels as much as 200 kilometers above the ground.

The latest data from some of these flights are summarized by two articles in the *Ninth Report* of the Council of International Scientific Unions' commission on solar-terrestrial relationships (Paris, 1957). Most of this work has been done by a group of physicists at the Naval Research Laboratory, Washington, D. C.,

including J. Kupperian, Jr., E. T. Byram, T. A. Chubb, and H. Friedman. I am indebted to Dr. Friedman for information concerning their most recent studies.

In the first high-altitude attempt to measure the ultraviolet light of the night sky, an Aerobee rocket was fired from White Sands Proving Ground on November 17, 1955, at two o'clock in the morning. Because it was expected that the diffuse ultraviolet radiation would be very weak, the rocket did not carry a conventional spectrograph to observe the night sky. Instead, it was equipped with several light-photon counters, the most important of which were two detector tubes filled with nitric oxide, a gas which is ionized by photons only if their wave lengths are shorter than 1350 angstroms. The ionization allows an electric current to pass through the tube, its strength indicating the intensity of the night-sky radiation at wave lengths below 1350 angstroms.

One of these detectors was fitted with a window of lithium fluoride (LiF), transparent between 1050 and the nitric-oxide cutoff at 1350, hence transmitting Lyman-alpha light at 1216. The other



These are the response curves for two nitric-oxide photon counters, one with a calcium-fluoride window (short, high curve), the other with a lithium-fluoride window. Only the second arrangement records Lyman-alpha light.

nitric-oxide tube had a calcium-fluoride (CaF_2) window, opaque for wave lengths shorter than 1230. Thus, this second detector could respond to radiation between 1230 and 1350, but not to Lyman alpha.

An important auxiliary device was the electron-beam tube used in the rocket. The electrons in the beam are affected by the magnetic field of the earth, and thus indicated continuously during the flight the direction of the rocket's axis with respect to the earth's field.

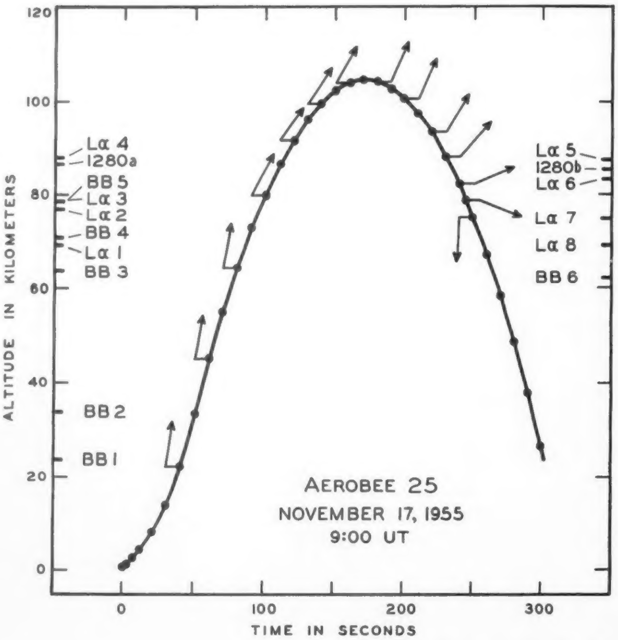
The spin of the rocket around its axis made it further necessary to determine the position of the horizontal plane with respect to the axis at every instant, in order to find the exact part of the sky toward which the detectors were pointing. This information was obtained by a special photomultiplier, sensitive to visible and near-ultraviolet light. The photomultiplier, which looked through a window at the airglow, gave the greatest response when the window pointed at the horizon, toward the maximum apparent thickness of the airglow layer.

In another night flight, on March 28, 1957, an Aerobee reached a height of 146 kilometers. "The rocket's motion approximated that of an arrow with the rocket attaining a horizontal attitude shortly after the peak of the flight," the NRL scientists reported. As with the 1955 ascent, photon counters were used with LiF and CaF_2 windows pointing outward perpendicularly to the rocket axis. The spin and yaw motions of the rocket permitted almost a complete scan of the sky.

At the right, altitude is plotted against flight time for the November 17, 1955, ascent of Aerobee No. 25. Arrows show the direction of the rocket's spin axis with respect to the vertical. The key on the left and right sides indicates photon-counter responses at various altitudes.

These events are marked BB for the broad-band counter, which first responded at BB 1; it was saturated from BB 2 to BB 3; at BB 4 it saturated looking up, and at BB 5 looking down. At BB 6 during the descent, the broad-band counter showed strong transient responses. Between the points 1280a and 1280b, the calcium-fluoride counter could see the Milky Way (see illustration on facing page).

Events marked Lα refer to the Lyman-alpha counter. It first responded at Lα 1 while looking up, and at Lα 2 while looking 20° down; at Lα 3 it saturated looking up, and at Lα 4 while looking 36° down. Still looking downward, at Lα 5 it came out of saturation and last responded at Lα 6. At Lα 7, looking upward, it came out of saturation, and last responded in that position at Lα 8.



An Aerobee-Hi rocket is being raised into position on the afternoon before its firing from the launching tower at Holloman Air Force Base. At its lower end may be seen the vanes of the booster motor, which drops away shortly after takeoff.

The 1230-1350-angstrom counter, the one *not* affected by Lyman-alpha photons, recorded no atmospheric emission in its wave-length range. Yet its telemetered record, reproduced here, made when the 1955 rocket was near the peak of its trajectory, may become a historic document marking a major advance in astronomy, for it is believed to be the first observation of the light of the stars at wave lengths shorter than 2000 angstroms.

As the rocket rolled, the detector first looked downward at the night side of the earth, no radiation being recorded. Then when it turned upward, one of the humps on the record occurred as the

detector swept across the Milky Way; the successive humps are not exactly alike because the scans did not cross the same part of the Milky Way.

But the most important features of this record are the tiny but easily distinguishable peaks on either side of the Milky Way humps. These are discrete sources of 1230-1350-angstrom radiation, most of which the NRL scientists have identified with celestial objects. The brightest of these, the Orion complex of hot stars and nebulosities, produced a flux at the top of our atmosphere of about 2×10^{-5} erg per square centimeter per second. (For comparison, the flux of sunlight over all wave lengths is about 10^{6} of the same units.) Dr. Friedman points out, "It appears to be entirely feasible to determine a map of stellar magnitudes in the extreme ultraviolet by means of photon counters."

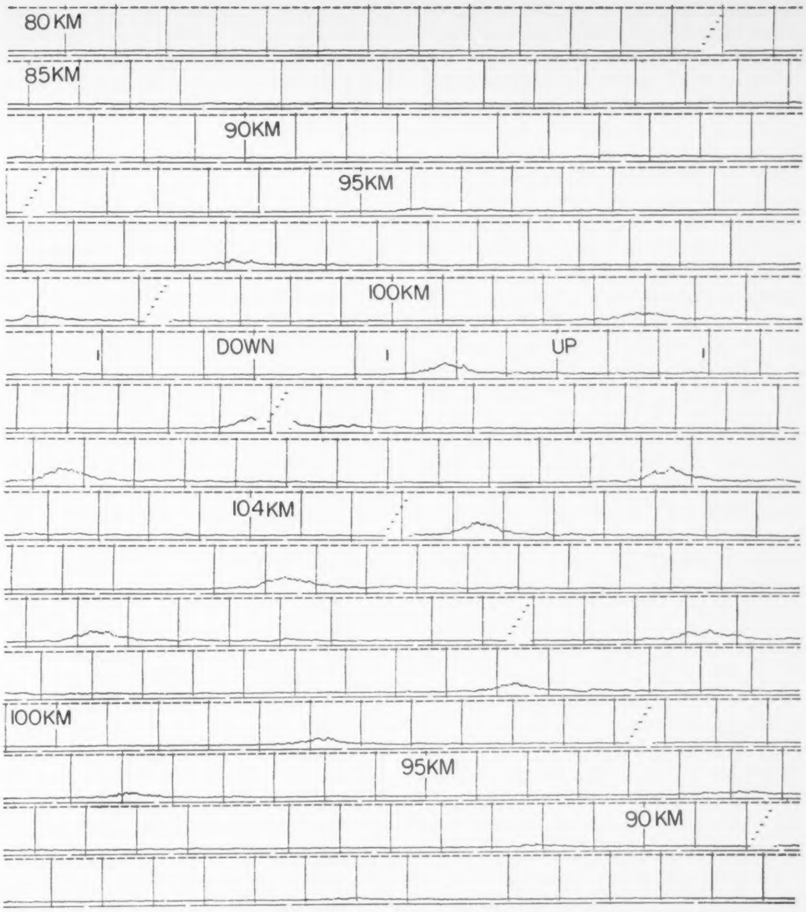
Of course, we do not yet know whether this radiation is continuous or whether it consists of emission lines. In all probability, the continuous spectra of the hotter stars contribute to it. According to Wien's law, the wave length, λ, at which the continuous spectrum of a star is brightest is inversely proportional to the surface temperature, T:

$$T = 3 \times 10^{7}/\lambda.$$

If this wave length is taken as 1280 angstroms, T is about 23,000° absolute. Hence all early B-type stars would be very effective in producing the observed radiation. But even cooler stars, such as the sun or Betelgeuse, may have emission lines near 1280 angstroms and thus may also contribute appreciably to this far-ultraviolet radiation.

In contrast to the record of the night-sky radiation between 1230 and 1350 angstroms, the chart reproduced below shows part of a telemetering record obtained with the LiF window. Although this detector could record both Lyman-alpha light and the 1230-1350-angstrom range, the latter contributed less than two per cent of the total. It appears virtually certain that this record shows almost exclusively Lyman-alpha radiation, from neutral hydrogen gas.

We notice that for every roll of the rocket there is a minimum of radiation when the window points down to earth, but as this minimum intensity is not zero our own atmosphere must be radiating Lyman alpha outward into space. Presumably, hydrogen atoms in the upper atmosphere are somehow excited from outside by interplanetary Lyman-alpha photons, and then the hydrogen atoms



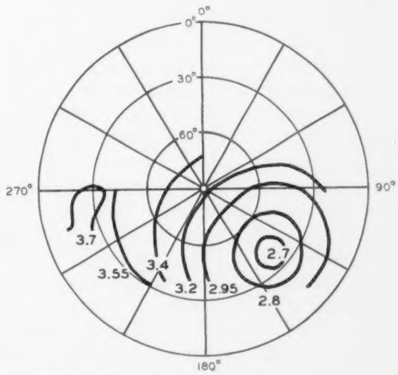
Tiny irregularities on this telemetry record of 1230-1350-angstrom radiation are the first observations of starlight at wave lengths shorter than 2000 angstroms. Large humps are due to light from the Milky Way. The record was obtained in the Aerobee flight of November 17, 1955. All diagrams with this article are courtesy Naval Research Laboratory.

re-emit this same kind of radiation back into space.

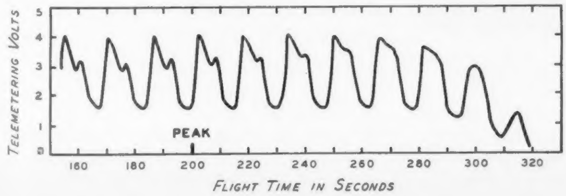
The intensity trace also shows secondary minima, which occurred whenever the window pointed to the part of the sky directly opposite the sun. This suggests that the Lyman-alpha radiation coming from above originates from interplanetary hydrogen excited by solar emission.

Important information is given by the accompanying plot of the distribution of Lyman-alpha intensity over the sky, with the zenith at the center of the chart. The distribution is symmetrical with respect to the antisolar point. There are also weak effects in the west from the Orion complex and from the galaxy, which probably also radiates Lyman alpha.

The symmetry of the contour lines of equal brightness strongly suggests several facts. First, the original source of the radiation appears to be the sun itself. Second, the hydrogen gas in interplanetary space seems distributed more or less symmetrically with respect to the sun; there is no conspicuous concentration



The distribution of diffuse Lyman-alpha radiation over the night sky is shown in this chart, centered on the zenith. Lines of equal intensity are labeled in units of 0.001 erg per square centimeter per second per steradian. The grid shows altitude and azimuth.



Made during the Aerobee flight of March 28, 1957, this record from a lithium-fluoride photon counter shows Lyman-alpha light of the sky and the atmosphere.

toward the average plane of the planets' orbits. Third, although interstellar neutral-hydrogen regions are detectable, they do not provide the major portion of the observed diffuse radiation.

The value of the flux of solar Lyman-alpha radiation at the earth's distance from the sun amounts to about three ergs of energy passing through one square centimeter each second of time. From this fact, we may roughly predict the resulting brightness of the diffuse 1216-angstrom light of the night sky.

We do not know just how many hydrogen atoms there are per cubic centimeter of interplanetary space, but estimates of the order of 500 are often mentioned. Most of these atoms are ionized, yet the percentage is difficult to compute. The clouds of solar particles that often reach the earth and which may produce auroral displays and magnetic storms must be very highly ionized. As a guess, at any instant there may be 5,000 times as many protons as neutral hydrogen atoms in the interplanetary gas. This would give 0.1 neutral hydrogen atom per cubic centimeter, capable of absorbing a solar Lyman-alpha photon.

From the spectroscopic observations by R. Tousey and his NRL coworkers, we know that the effective width of the solar Lyman-alpha line is about one angstrom unit. Each interplanetary neutral hydrogen atom acts as a little absorbing screen whose cross-sectional area is approximately 10^{-14} square centimeter. This screen is opaque over a wave-length range of half an angstrom on each side of the center of the line, and is comparatively transparent for other wave lengths. Hence, each atom would absorb about 3×10^{-14} erg from the solar Lyman-alpha flux. With only 0.1 neutral hydrogen atom per cubic centimeter, the energy absorbed by this volume would be 3×10^{-15} erg. Then the excited hydrogen atoms would re-emit this radiation uniformly in all directions. Within a solid angle of one steradian (about 1/12 the total area of a sphere), the re-emitted energy would be roughly 10^{-16} erg.

If both the hydrogen gas and the solar radiation are uniform in interplanetary space, a layer of the gas one astronomical unit thick (10^{13} centimeters) would in this way scatter enough solar Lyman alpha to produce a diffuse emission of about $10^{-16} \times 10^{13}$, or 10^{-3} erg per square centimeter per second at the earth. This is of the same order of magnitude as the actually observed value, as indicated in the intensity chart of the entire sky.

However, this estimate is exceedingly uncertain. Most hydrogen atoms ejected by the sun are probably driven out of the solar system at very high speeds by radiation pressure and, perhaps, other forces, just as gases from comet tails are driven away. Certainly, many of the solar protons reaching the earth are moving at hundreds or thousands of kilometers per second. When these protons recombine with electrons to form neutral atoms, they should not be sensitive at all to solar radiation of 1216 angstroms. The Doppler effect of their motion away from the sun would make them capable of absorbing radiation of about 1220 angstroms instead, but this part of the sun's continuous spectrum is faint.

There is another possible source for the diffuse Lyman-alpha emission from the night sky, by what is known as the Zanstra mechanism. When ionized hydrogen atoms recombine with electrons, the latter cascade from higher excited levels down to the second level; then the final step may occur, from the second to the first energy level, with the emission of Lyman-alpha light.

Many other possibilities are suggested by these very important NRL night-rocket results, but perhaps we should wait until more observations have been obtained with rockets, and even with artificial satellites.

I wish to record my indebtedness to my colleagues at Berkeley: L. G. Henyey, P. Sweet, and S. S. Huang, with whom I have discussed many aspects of this problem besides those described in this article.

GETTING ACQUAINTED WITH ASTRONOMY

(*Continued from page 444*)

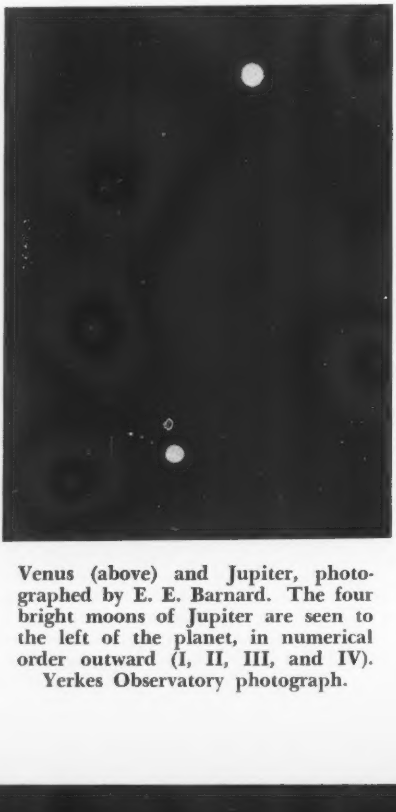
may even be detected in binoculars. These phenomena are repeated in the morning sky, in reverse order.

During much of the time, Venus can be seen in the daylight hours, although optical aid may be required unless very clear skies prevail or the planet is at its brightest. If the moon passes near Venus, the point of light that is the planet is more easily found by reference to the bright lunar crescent.

Mars makes a complete cycle between oppositions in about 26 months, during which time its light varies considerably. At opposition, it is an outstanding object and sometimes, when nearest to the earth, Mars is second only to Venus in brilliancy. But if Mars is near the sun in the sky, it is about 2nd magnitude and is relatively inconspicuous, though even then it is distinguished by its decidedly red color. Compare the hue of Mars with the reddish stars Aldebaran, Antares, and Betelgeuse as it travels past them, for they are in or near the zodiac.

Anyone who is doing systematic observing should keep a notebook. If the position of Mars is marked on a star map about once a week around the time of opposition, the well-known phenomenon of retrograde motion becomes apparent. The same is true for any of the superior planets, but more so for Mars.

Jupiter, with its retinue of four satellites bright enough to be seen in amateur instruments, is probably the favorite among the planets for those who observe with small telescopes and binoculars. With eight power all four of these moons can be detected if none is too close to the bright planet. In telescopes the disk of Jupiter is seen noticeably elliptical, with cloud belts banding the planet parallel to its equatorial or longer diameter, which varies from 30 to 50 seconds. Distinctly yellow, Jupiter is never fainter than magnitude −1.0, and at opposition attains −2.5.



Venus (above) and Jupiter, photographed by E. E. Barnard. The four bright moons of Jupiter are seen to the left of the planet, in numerical order outward (I, II, III, and IV). Yerkes Observatory photograph.

Saturn, perhaps the most beautiful telescopic object in the solar system, has little to offer the naked-eye observer. Its apparent motion is very slow, as it takes 29½ years to travel once around the sky. With 7-power binoculars an elongation of the disk due to the rings is just noticeable, but at least 20x is necessary to reveal the rings themselves. A power of 100 or more is needed, however, to bring out the true beauty of the planet and its rings. During Saturn's orbital revolution, the form of the rings changes as we see them, from edge-on to a tilt of 27°, when either the north or south face of the rings is well exposed for study. Saturn has nine satellites, and several of them are easily seen in amateur telescopes.

Uranus and Neptune, of the 6th and 8th magnitude, respectively, are within range of good binoculars. Charts of their paths among the stars are published in annual handbooks, and all observers will enjoy seeing these planets at one time or another. Pluto, the most distant known planet, is far too faint to be located with the average telescope used by amateurs.

(*To be continued*)

A Seeing Scale for Visual Observers

CLYDE W. TOMBAUGH and BRADFORD A. SMITH

New Mexico College of Agriculture and Mechanic Arts

THERE are many systems in use by visual observers of planets and double stars to designate the quality of astronomical seeing, usually on a numerical scale of 0 to 5 or 10. Nearly all these systems are oversimplified or merely subjective. What appears to be "perfect seeing" to an observer using a small telescope, and described by him as 10, may be only mediocre to the user of a large instrument, who might record the same seeing as only 4 on a 0-to-10 scale.

For observations of planetary detail, the 0-to-10 scale was adopted by the first author on the advice of E. C. Slipher, Lowell Observatory. These two observers' independent estimates of seeing quality on planetary disks were quite consistent, seldom differing by one step. Since then, Tombaugh has had experience with astronomical seeing in localities as varied as Illinois, Kansas, Arizona, California, New Mexico, Texas, and Ecuador. There was good and bad seeing in all of them; the best and the worst were both at Flagstaff, Arizona, where most of the observing was done.

The worst seeing experienced was on the night of January 21, 1930, when the first search plate of that year for Pluto was being taken with the Lowell Observatory's 13-inch photographic refractor. During the one-hour exposure the guide star was 3rd-magnitude Delta Geminorum, which was watched through the 7.3-inch guide telescope with a 171x eyepiece. At the start of the exposure, the guide star appeared slightly swollen from the seeing, which was estimated as 1 to 2 on a scale of 10. Ten minutes later the slight northeast wind suddenly increased to a violent gale. With each fierce gust, the image of Delta Geminorum quickly swelled to three or four times the apparent diameter of Jupiter and disappeared! After several seconds of total invisibility, the guide star would suddenly reappear as a small fuzzy ball on the illuminated cross threads in the eyepiece. The seeing was so much worse than what we normally call 0 that the need for an extension of the seeing scale to negative values became an obvious necessity.

Some time ago, the first author compared the different steps of seeing for planetary detail with the corresponding angular sizes of image blur. A logarithmic relationship was found between them, analogous to that between stellar magnitude and star brightness. Seeing steps of 1, 3, 6, and 9, as estimated by him, corresponded to angular blurs of 5, 2, $\frac{1}{2}$, and $\frac{1}{8}$ seconds of arc, respectively. (Seeing 9 is so rare that he has seen it less than a dozen times in 25 years of observing.) Thus, for every three steps of improvement in seeing there was a fourfold decrease in the diameter of the blur, a 16-fold decrease in its area.

Since a planetary disk may be regarded as a mosaic of such blurs, the amount of perceptible detail increases greatly with improved seeing. When the seeing reaches 8, the number of minute crater pits that become visible on the moon is surprising, and the sun's surface is resolved into countless "rice-grain" markings.

The experienced planetary observer can readily estimate the seeing to half a step because the amount of detail visible on a planet aids his judgment. While looking at a single star through the telescope, this aid is lacking, and it is hard to estimate the seeing directly to within closer than about two steps.

Double stars, however, offer a simple and accurate means of evaluating seeing. If the separation in seconds of arc is known for a double star, then the apparent star-image diameter can be estimated directly in seconds, and from this the step number of the seeing can be inferred. This gives a straightforward and objective way for independent observers, or for the same observer at different times, to make consistent evaluations of seeing on a unified scale.

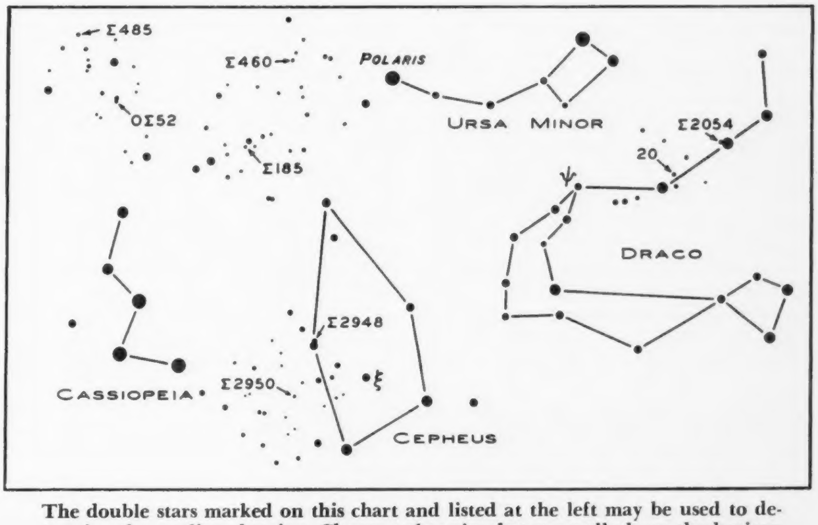
For observers in north temperate latitudes, double stars near the north celestial pole are especially convenient, because they may be seen at any time of night in all seasons. The second author has compiled the accompanying list of suitable double stars, and a conversion table giving seeing steps.

The method is illustrated by the following example. Suppose an observer looks at the double star Σ185, separation 1.3 seconds, and notes that the images of the two components just meet. Therefore the diameter of the apparent disks is 1.3 seconds, and the conversion table tells us that this corresponds to seeing of quality +4.

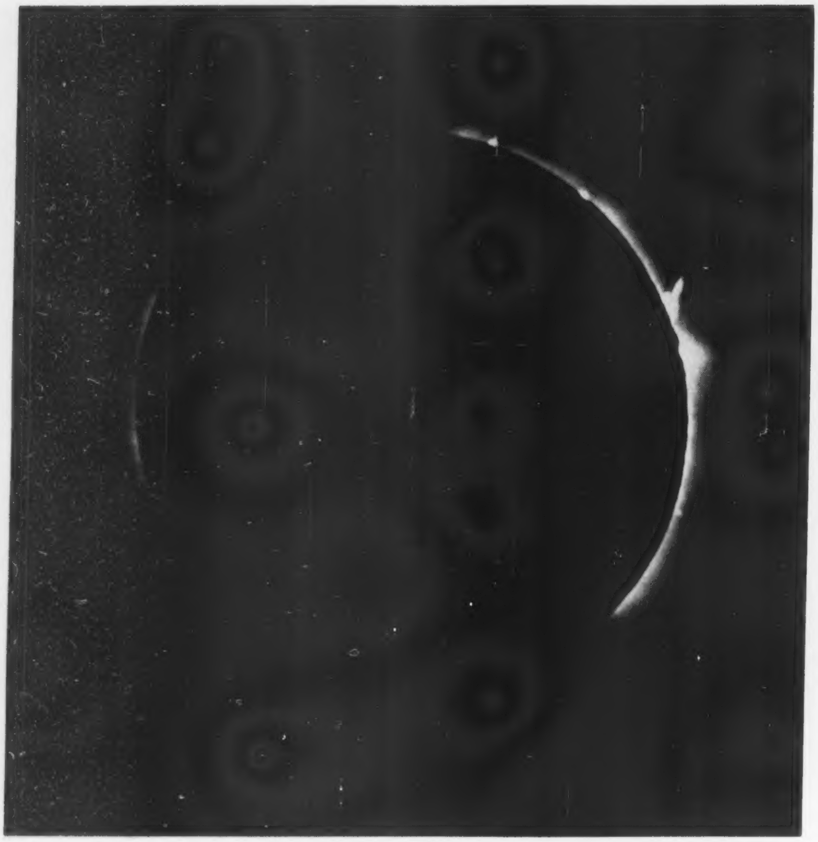
Usually during an observing session the quality of the seeing fluctuates. Should the observer record the seeing characterizing the best glimpses, an average value, or the predominant quality? For close double stars or planetary detail, it is the brief moments of very best seeing that count most. For some other purposes, such as designating the visual appearance of the guide star during a long-exposure photograph, the average seeing is more relevant. For 20 years, Tombaugh has tabulated the seeing in his records by writing a series of numerals, using larger script for the more frequently occurring values.

Seeing Quality	*Image Diam.*	*Seeing Quality*	*Image Diam.*
−4	50″	+3	2″.0
−3	32	+4	1.3
−2	20	+5	0.79
−1	12.6	+6	0.50
0	7.9	+7	0.32
+1	5.0	+8	0.20
+2	3.2	+9	0.13

Double Star	*Magnitudes*	*P.A.*	*Sep.*
ψ Draconis	4.0 - 5.2	15°	30″.6
Σ485	6.1 - 6.2	304	18.3
ξ Cephei	4.7 - 6.5	279	7.3
Σ2948	7.0 - 8.7	5	2.8
Σ2950	6.0 - 7.2	302	2.3
Σ185	7.0 - 8.5	20	1.3
Σ2054	5.7 - 6.9	355	1.2
Σ460	5.2 - 6.1	65	0.9
20 Draconis	6.5 - 7.1	78	0.6
OΣ52	6.4 - 7.0	94	0.5



The double stars marked on this chart and listed at the left may be used to determine the quality of seeing. Choose only pairs that are well above the horizon for estimating image diameter.



This white-light photograph of the 1952 eclipse records the inner corona and the chromosphere. The bright prominence spike at the right indicates an active region near the sun's edge; it can be seen in the spectrum at the foot of this page. U. S. Naval Research Laboratory photograph.

Observing Plans for October's Eclipse — II

ROBERT J. LOW, *High Altitude Observatory*

FOR SOLAR ASTRONOMERS, the total eclipse visible from the South Pacific this October 12th provides a rare opportunity: Eclipse observations by powerful new techniques will be possible for the first time during a period of high solar activity. In addition, the value of the results will be enhanced because the eclipse studies are part of the extensive solar program of the International Geophysical Year.

As stated last month, the American expeditions to the October eclipse will go to the Danger Islands, an atoll group which is one of the very few land areas crossed by the narrow path of totality. Total eclipse there lasts for four minutes, with the midmorning sun at an altitude of about 45° — these are highly favorable circumstances. We have already described how the Naval Research Laboratory expects to send six rockets aloft during the eclipse to measure ultraviolet and X-ray emission from the sun, and how the National Bureau of Standards will study the reflection of radio signals from the earth's ionosphere. But these experiments are only a part of astronomers' plans for October 12th.

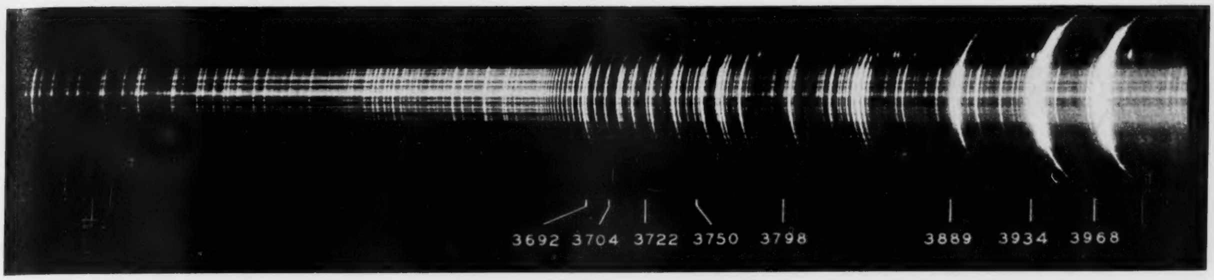
Three kinds of optical observations will be attempted at the Danger Islands. Two of these concern the solar corona, and the third involves rapid-sequence photography of the flash spectrum. All three programs are elements of a concerted attack on the problem of physical conditions in the sun's atmosphere.

J. E. Mack and D. H. Liebenberg, of the University of Wisconsin, are developing instruments for measuring the profiles and absolute intensities of the green coronal line at 5303 angstroms and the yellow line at 5694. These two bright lines arise, respectively, from iron atoms that have lost 13 electrons and calcium atoms that have lost 14.

The scientists will use a Fabry-Perot interferometer, a device giving very high dispersion over a quite limited range of wave lengths. Such dispersion for the 5303 line is usually possible only during a total eclipse; at other times, the sky background is too bright, even using coronagraph techniques. The yellow coronal line at 5694 angstroms poses a challenge, since the coronagraph reveals the line only near areas of great solar activity. It is by no means certain that there will be a highly active region at the sun's edge on eclipse day, even though this occurs near solar maximum. In the absence of such a region, will the yellow emission line be observable at all? There is some indication that the 5694 line is associated with *all* complex sunspot groups; very little, however, is known about the strength of this emission as a steady-state phenomenon.

In fact, astonishingly little is known about the physical conditions in even the most commonly observed coronal phenomena. The most fundamental questions remain to be answered. For example, if the temperature of the quiet corona is computed from the relative intensities of the iron-XIV and iron-X emission lines, the result is about 700,000° absolute. On the other hand, calculations based on measurements of the profiles of these lines yield temperatures ranging from 1.6 to 2.5 million degrees. There is no entirely consistent explanation of this discrepancy. Another outstanding problem: Does the great width of the coronal spectrum lines arise solely from high temperature? Or is it also due to streaming of matter, or to random turbulence,

Compare this spectrum of the 1952 eclipse with the white-light picture above. The bright prominence spike is seen at several wave lengths, particularly in the three magnesium lines (5167, 5172, and 5184 angstroms), to the right of center. At the extreme right is the strong green coronal 5303 line, and at the left hydrogen beta (4861 angstroms). High Altitude Observatory photograph.



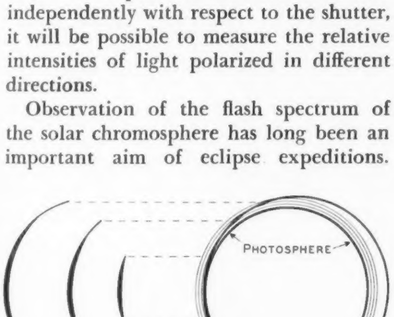
The High Altitude Observatory's expedition to Khartoum obtained this high-dispersion flash spectrum during the 1952 total eclipse. Each curved bright line is a monochromatic image of the sun's chromosphere at a particular wave length. The longer the curve, the higher the solar level from which the light arises; stronger lines also appear longer. The labels are aligned tangent to the corresponding lines. The H and K lines of ionized calcium at 3968 and 3934 angstroms, respectively, are strong high-level lines. Also marked here are some hydrogen lines, ultraviolet members of the Balmer series. Many other lower-level lines are due to iron and other metals.

or to both of these particular phenomena?

The Wisconsin team will attempt to compile maps of the corona as it appears in the yellow and green emissions. They hope to obtain measurements farther out in the corona than heretofore, in order to study the change of temperature with height. This project is being financed by a grant from the National Science Foundation.

Another kind of coronal observation is planned by the joint expedition of the California Academy of Sciences and the U. S. Naval Radiological Defense Laboratory, under the leadership of G. W. Bunton. This group will measure the intensity of the white-light corona (light from the solar photosphere scattered by the free electrons in the corona) at large distances from the sun's surface. Their instrument is a camera of 20 inches focal length, with a sector-type shutter which rotates together with a sheet of polaroid. Because the polaroid can also be turned independently with respect to the shutter, it will be possible to measure the relative intensities of light polarized in different directions.

Observation of the flash spectrum of the solar chromosphere has long been an important aim of eclipse expeditions.



To illustrate the geometry of formation of the flash spectrum, several layers of the sun's atmosphere are indicated in this diagram. When the moon is just tangent to one limb of the photosphere, the latter's continuous spectrum cannot be seen, so the bright emission lines of the chromosphere flash out at various wave lengths. Since the moon is covering more of the lower chromosphere, the observed crescent lengths are greater for higher chromospheric levels. The diagram is not to the correct relative scale.

The brightest lines, such as H and K, are better rendered in the spectrum at the right, which was given only 1/100 the effective exposure of the one above.

Few problems require preparations so elaborate for observations so brief. The strongest flash-spectrum lines are visible for only about 50 seconds at any one eclipse; the majority of the weaker lines are observable for only three to four seconds in all. Yet two or three years may have to be spent on preparation of the equipment!

The flash spectrum takes its name from the dramatic moment at the very beginning of totality, when the dark lines of the Fraunhofer spectrum of the sun's atmosphere change with spectacular suddenness to the bright lines of chromospheric emission. What actually happens is that the continuous emission of the photosphere is cut off abruptly by the edge of the moon, and the chromospheric lines, which had looked dark against the bright continuous background, suddenly appear bright.

The U. S. Air Force is sponsoring a joint expedition from Sacramento Peak Observatory and the High Altitude Observatory to investigate the flash spectrum. The Sacramento Peak team is under the direction of its superintendent, J. W. Evans, while J. H. Rush is leading the group from HAO.

This phenomenon was observed by the HAO expedition to Khartoum, Sudan, for the 1952 eclipse. Dr. Evans led that party and was responsible for the overall design of its instruments. His experience has been invaluable in planning the equipment for 1958.

The 1952 flash-spectrum observations are highly informative. In the first place, they imply that the outward temperature rise, from 6,000 degrees at the solar surface to one or two million degrees in the corona, may occur in the chromosphere in discontinuous steps, corresponding to the temperatures where hydrogen and helium radiate most efficiently. In the second place, there seem to be discontinuities along any one level of the chromosphere, which are not yet fully explained. It is known that there are spicules in the high chromosphere, but the discontinuities are also seen in the lower chromosphere. These may be associated with the granules of the photosphere, but there is much uncertainty about this point, and it needs intensive study at future eclipses.

To get detailed information on how the properties of the chromosphere change with height, the observations should be able to distinguish between chromospheric levels about 100 kilometers apart. This cannot be accomplished with a coronagraph, because of the blurring from poor seeing in its "artificial eclipse." But if the eclipse is produced outside our atmosphere, the desired height discrimination is possible — provided the pictures are taken in very rapid succession.

Basically, the equipment consists of a triple spectrograph to cover three spectral ranges: 3300 to 6600 angstroms (which includes the ultraviolet), 3600 to 4900 for visible light, and 5000 to 9300 (including the near infrared). The respective dispersions will be $5\frac{1}{2}$, 2, and $5\frac{1}{2}$ angstroms per millimeter. The three dispersing elements will be fed sunlight by a single coelostat, and each will have a double camera unit. The individual cameras will take one frame each 0.6 second; exposure time is 0.2 second, while film transport and shutter action together require 0.4 second. Thus by alternately operating the cameras in each pair, an exposure of each spectral range can be made every 0.3 second.

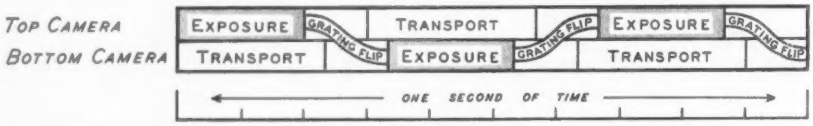
Each camera-film frame will contain three separate spectra whose intensities are to be in the ratio 1 to 20 to 400, and

also the image of a step wedge illuminated by a lamp for relative photometric calibration. Absolute calibration is to be provided by exposing, through the same optical system, suitably attenuated spectra of the sun itself, both before and after the eclipse. Each frame will carry a serial number, for matching the data (such as time and length of exposure) that are to be imprinted on a multi-channel recorder.

The total amount of film that must be handled is enormous, since every 0.3 second each camera pair will expose another frame measuring 26 by seven inches, with its three spectra. All this, with the additional calibration spectra, will consume more than 1,000 square feet of film for the eclipse.

The ultraviolet and infrared spectrographs will be slitless instruments, but with broad slots to reject coronal light from the opposite side of the sun. The visible-light spectrograph, for line-profile observations, will have a curved slot that will admit light from the entire chromosphere but block off the coronal emission from both sides of the sun. The slots will be 135 degrees of a circle in length, extending from 45 degrees on one side of the diameter parallel to the line of contacts to 90 degrees on the other side. The diameter of the image of the solar limb will be 54 millimeters for the visible spectra, and 45 for the ultraviolet and infrared.

During times of high solar activity, the outer corona has a generally rounded appearance, as seen in this picture of the 1937 eclipse, taken by Maj. A. W. Stevens. The solar corona in October will probably have a form resembling that of the eclipse above.



For the 1958 flash-spectrum program, each of the three spectrographs has two cameras, which record spectra alternately according to this schedule. During the film-transport period between exposures, the diffraction grating shifts to throw light into the other camera.

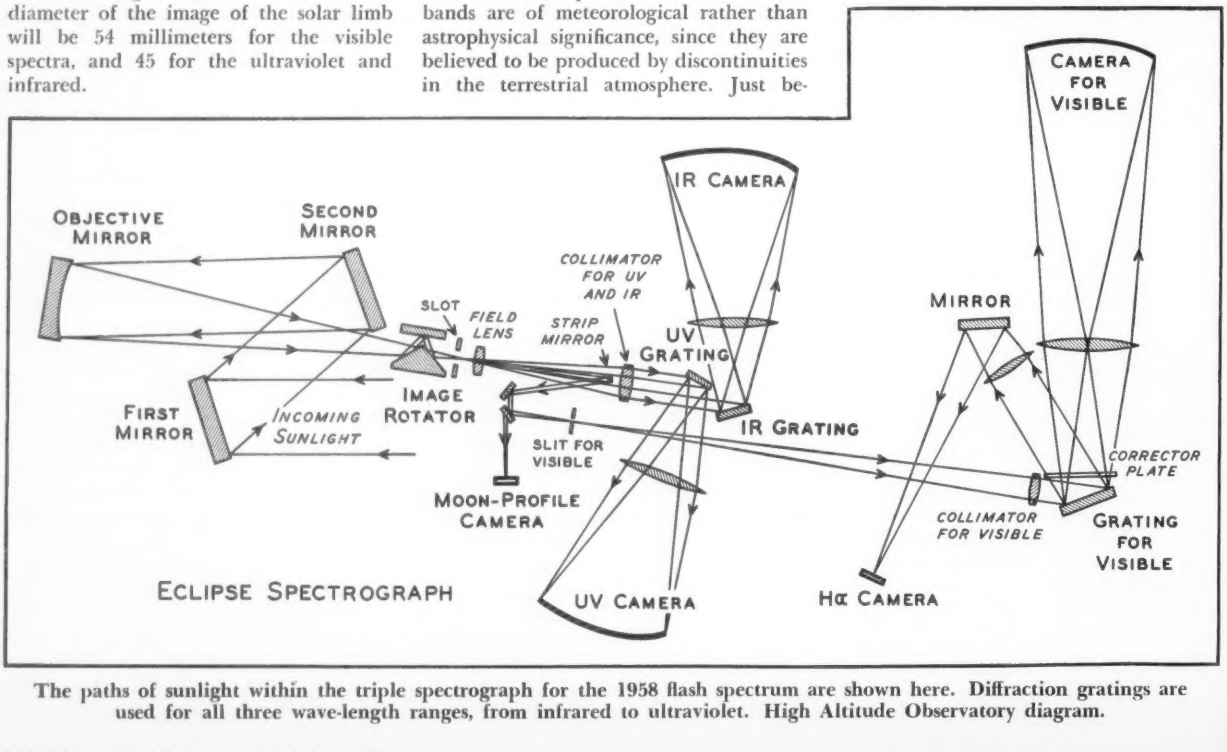
The last American experiment is of an entirely different type — the study of eclipse shadow bands. This is another program of the California Academy-Radiological Laboratory group, and is under the leadership of C. P. Butler. Shadow bands are of meteorological rather than astrophysical significance, since they are believed to be produced by discontinuities in the terrestrial atmosphere. Just before second contact and after third contact, when the shadow bands occur, they will be measured by photronic cells, the outputs being recorded by a Helland oscillograph.

Besides the U. S. contingent to the Danger Islands, at least two eclipse expeditions from other nations are definitely planned. Japanese astronomers have recently announced a very extensive program of astrophysical and geophysical observations to be made from Suwarrow Island, some 200 miles southeast of the Danger group. Some details have been provided by Yoshio Fujita, who is secretary of the eclipse committee of the Science Council of Japan.

Tokyo Observatory plans spectrophotometric studies of the solar chromosphere and corona, as well as photographic observations with a quadruple telescope to measure the polarization of the corona. As a third project, the Tokyo astronomers will make photoelectric measurements of the zodiacal light and airglow. Parties from Kyoto and Tohoku universities will observe, respectively, the flash spectrum and the corona. Other Japanese programs include determination of contact times by visual, photographic, and photoelectric methods, and recording changes in the earth's magnetic field during the eclipse.

Russian astronomers have indicated that they also will make eclipse observations, but it is not yet known what work will be undertaken or where their instruments will be set up.

From this listing of varied programs, it appears that the October 12th eclipse will almost certainly be one of the best observed solar events in history.



The paths of sunlight within the triple spectrograph for the 1958 flash spectrum are shown here. Diffraction gratings are used for all three wave-length ranges, from infrared to ultraviolet. High Altitude Observatory diagram.

Amateur Astronomers

SOUTHEAST CONVENTION

The Rocket City Astronomical Association was host to more than 100 members and guests, representing seven amateur societies in four states, who attended the Southeast regional convention of the Astronomical League at Huntsville, Alabama, on May 10-11.

Some of the Huntsville members who gave talks were: Conrad Swanson on satellite lifetimes, Wilhelm Angele on the society's activities, William Edens on radio signals from Vanguard, and C. L. Bradshaw on high-speed calculations of Explorer orbits. In addition Leonard Abbey, Decatur, Georgia, talked on observing Mars, and Tommy Brooke told of the Atlanta junior club activities. The Jacksonville, Florida, Astronomy Club's two motion pictures of the moon were presented, in addition to the film, X Minus 80 Days, produced by the Army Ballistic Missile Agency and the Jet Propulsion Laboratory.

At the convention banquet, current activities and growth of the league were outlined by its vice-president, C. H. Holton, and Dr. Wernher von Braun spoke briefly on space research. The main speaker was Dr. Armand N. Spitz, who reported on MOONWATCH activities.

Exhibits included a full-scale model of Explorer I, a model by the Atlanta juniors demonstrating stellar distances from the sun, and a photograph album of amateur telescopes compiled by B. L. Harrell, Gadsden, Alabama. During the meeting, the delegates made a tour of the Huntsville society's Monte Sano Observatory.

Elected as regional officers were: Llewellyn Evans, Chattanooga, Tennessee, chairman; the undersigned, vice-chairman; P. O. Parker, Griffin, Georgia, secretary; and Robert L. Paine, Atlanta, treasurer.

JOHN A. EBEL
2973 Downing St.
Jacksonville, Fla.

MICHIGAN AMATEUR DIES

The founder of the Grand Rapids Amateur Astronomical Association, James C. Veen, Sr., passed away on May 18th from injuries sustained in an automobile accident. He was 60 years old, and had been an active amateur astronomer since 1910. He started the Grand Rapids, Michigan, society in 1954, had served as its president, and was secretary at the time of his death.

YONKERS, NEW YORK

A group of 42 amateurs have organized the Hudson River Museum Astronomy Club in Yonkers, New York. Half of the members are juniors, who have a separate section for their own activities. Interested persons should contact John A. Yules, 616 E. Lincoln Ave., Mt. Vernon, N. Y.

NORTH CENTRAL CONVENTION

With the Milwaukee Astronomical Society as host, the 12th annual convention of the North Central Region of the Astronomical League was held on May 12th, at the new YMCA auditorium in the Wisconsin city. There were 155 registrants representing 12 societies in three states.

Dr. S. C. Moske, St. Paul, Minnesota, described a trip to the moon. Benjamin Miller of J. W. Fecker, Inc., spoke on amateur instruments and explained the optical design of Igor, a missile-tracking camera. Observing techniques and astrophotography were discussed by Dr. Theodore Houck, University of Wisconsin.

Leaders of various MOONWATCH stations told of their equipment and techniques for satellite tracking. The junior session, which was well attended by young amateurs, was presided over by Tim Wyngaard, Madison Junior Astronomical Society.

New officers for the region are: H. B. Porterfield, Madison, chairman; Richard R. Fink, Milwaukee, vice-chairman; Mrs. Ralph Buckstaff, Oshkosh, Wisconsin, regional representative; and the undersigned, secretary-treasurer.

At the banquet Dr. Albert V. Shatzel, Adler Planetarium, gave a history of optical design. The meeting concluded with a star party at the Milwaukee society's observing site near New Berlin, where, despite cloudy weather, a sighting of Sputnik III was made.

JOSE HERNANDEZ
529 Mackubin St.
St. Paul 3, Minn.

"SPACE" MAGAZINE

Beginning with last April's issue, the *Junior Astronomer,* a publication of the Astronomical League, became an independent periodical, changing its name to *Space*. The magazine, which is issued monthly except during July and August, is edited and published by Benjamin Adelman, 4211 Colie Dr., Silver Spring, Md. A single subscription is 75 cents a year; group subscriptions, with a minimum of five and mailed to a single address, cost 50 cents each per year.

THIS MONTH'S MEETINGS

Dallas, Tex.: Texas Astronomical Society, 8 p.m., home of Ted F. Gangl, 7903 Mohawk Dr. July 28, field meeting.

Edinburg, Tex.: Magic Valley Astronomical Society, 8 p.m., Pan American College science building. July 18, motion picture, The Strange Case of Cosmic Rays.

San Antonio, Tex.: San Antonio Astronomy Club, 7:45 p.m., Memorial Hall, Witte Museum. July 25, John Newell, "Mirror Grinding."

SOCIETY LISTING

The September issue is tentatively scheduled to carry Here and There with Amateurs, the listing of all amateur groups that have registered with *Sky and Telescope*. Any changes in the previous listing, beginning on page 293 of the April issue, should be sent to this magazine by July 15th. Clubs that were not listed there and whose membership is open to the public should write for a registration blank.

GREAT LAKES CONVENTION

The new Robert T. Longway Planetarium at Flint, Michigan, will be the setting for the annual meeting of the Great Lakes Region of the Astronomical League on August 2-3. The Flint Amateur Astronomy Club and the planetarium are the hosts.

The theme of the convention will be "Entering an Age of Space." Dr. Charles H. Smiley, chairman of the department of astronomy, Brown University, is to be the principal speaker.

The Flint planetarium is the first public installation of the Spitz Model B projector in the United States. Another instrument of this kind is located at the Air Force Academy, Colorado Springs, Colorado.

TROY, NEW YORK

The 20th anniversary of the Rensselaer Astrophysical Society was celebrated on May 3rd by a reunion banquet of present and former members. A tour of the RPI radio astronomy station at Grafton was guided by Dr. Robert Fleischer, director of the observatory of Rensselaer Polytechnic Institute.

Principal banquet speaker was Dr. G. Howard Carragan, the founder of the society and for many years its faculty advisor. The meeting was concluded with two motion pictures, one American and the other Russian, dealing with the Explorer and Sputnik programs.

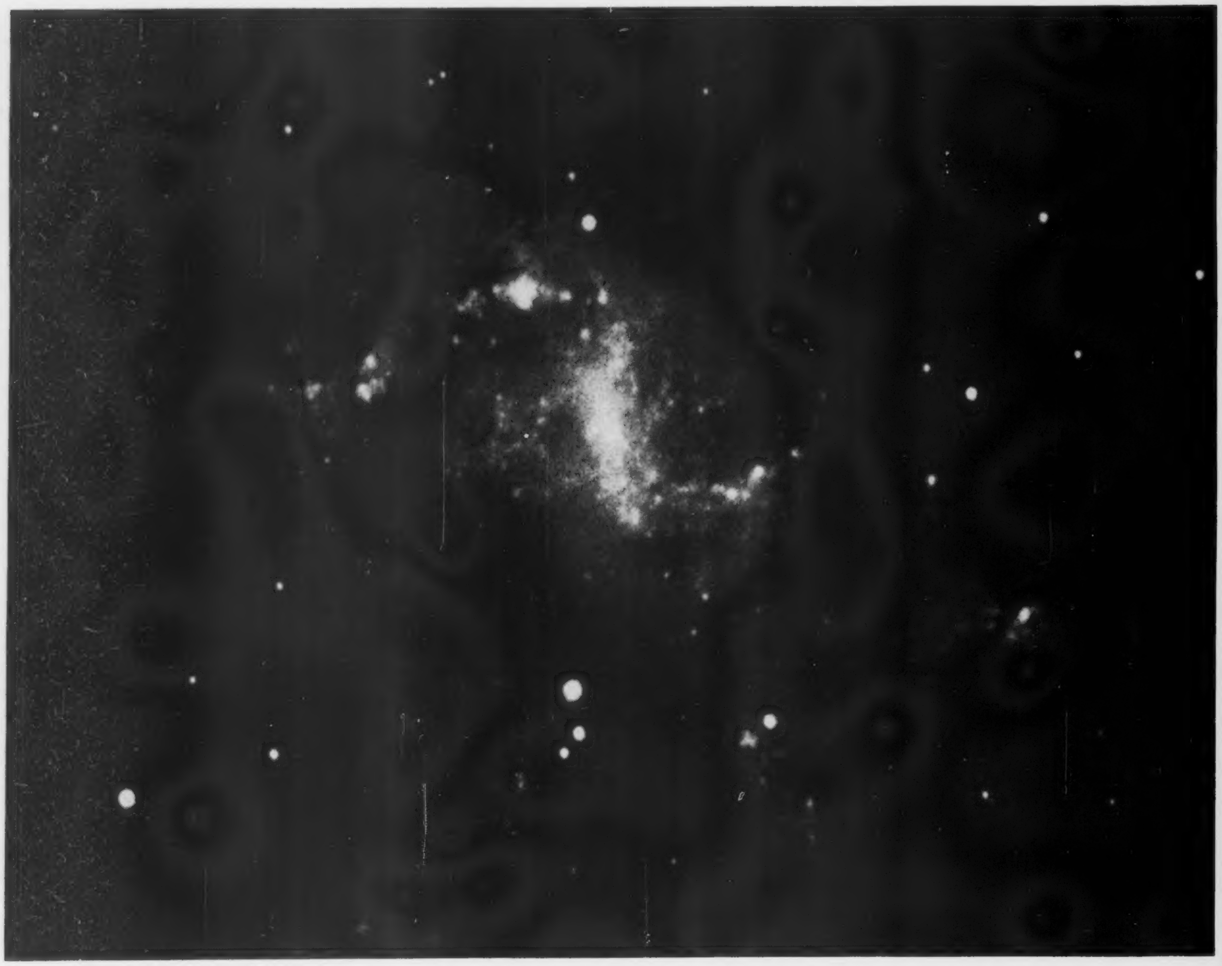
GERALD A. KING
Rensselaer Polytechnic Institute
Troy, N. Y.

STELLAFANE NOTES

On August 16th, amateur telescope makers again convene for their annual Stellafane meeting on Breezy Hill, Springfield, Vermont. The afternoon session will include talks by Stanley Brower on making eyepieces and Michael Glowa on optics in industry.

The evening program will feature color movies, shown by Frank Cooke, of the manufacture of advanced astronomical optics. Walter J. Semerau's slides and movies of solar prominences will also be presented.

Camping in a nearby pasture will be allowed on Friday and Saturday nights. Reservations for rooms or motels may be made with Mr. E. Merryfield, Hartness House, Springfield, Vt.



The late-type barred spiral NGC 1313, photographed with the 74-inch Radcliffe Observatory reflector on October 8, 1953. This is a one-hour exposure on Eastman 103a-O emulsion without a filter. The reproduction scale is 2.1 seconds of arc per millimeter; north is at the top. Numerous clumps of nebulosity appear in the arms, but little or no absorbing material.

Among Southern Galaxies—VI

THE GALAXY pictured at the top of this page is similar to NGC 986 shown here last month (page 404). NGC 1313 is another barred spiral, classified as SB(s)d by G. de Vaucouleurs.

Of photographic magnitude 9.5, it lies at right ascension 3^h $17^m.6$, declination $-66°$ $40'$ (1950 co-ordinates), just within the southwestern corner of the little constellation Reticulum, and is plotted in the Skalnate Pleso *Atlas of the Heavens*. A low-resolution photograph of this galaxy with the 30-inch Mount Stromlo reflector was reproduced in the September, 1957, issue, page 524.

The brighter, inner parts of the galaxy are $4\frac{1}{2}$ by three minutes of arc; however, outlying parts spread faintly over an area 10 by eight minutes. It is of very late type, intermediate between the regular SBc and the irregular (Magellanic) type SBm. Well resolved into stars of the 19th magnitude and fainter, and with many brighter emission knots, it appears to be about 10 million light-years distant. As yet the red-shift velocity has not been measured for this far-southern object. The integrated spectral type is probably *A* or *F*, similar to that of the Large Magellanic Cloud.

The facing picture is of two galaxies — NGC 1316 (lower) and 1317, in southeastern Fornax, at 3^h $20^m.7$, $-37°$ $25'$, and 3^h $20^m.8$, $-37°$ $17'$, respectively. The first is a peculiar-looking supergiant member of the Fornax cluster of galaxies. Dark lanes suggest traces of spiral structure, and on short exposures a narrow dark lane is seen across the nucleus. Dr. de Vaucouleurs classifies this 9.5-magnitude object as SAB(s)O peculiar, and gives the spectral type as *K*0 without emission lines; the maximum extent revealed by microphotometer tracings is over 20 minutes.

This galaxy is also a strong radio source (Fornax A), to which B. Y. Mills assigns a radio magnitude of 5.5.

NGC 1316's radial velocity is about +1,900 kilometers per second, and it appears to be about 30 million light-years away. The object is probably nearly resolved in this photograph.

The companion system, a few minutes south of NGC 1316, is at the same distance and has a similar recession velocity. NGC 1317 is also large, traceable to about 2.5 by 2.3 minutes. It has a very bright nucleus with inner spiral structure, or whorls of bright and dark matter on a very faint bar across a weak lens. It is intermediate in appearance between ordinary and barred spirals.

FACING PICTURE: NGC 1316 (bottom) and NGC 1317, companion galaxies in Fornax. This 90-minute exposure without a filter was made on November 17, 1955, with the 74-inch Radcliffe Observatory reflector on an Eastman 103a-O plate. Scale is 3.2 seconds per millimeter. This series of southern galaxies began in the February, 1958, issue, and is being published through the co-operation of R. H. Stoy, director of the Royal Cape Observatory, Cape of Good Hope, South Africa.

NEWS NOTES

TEXTURE OF THE MOON'S SURFACE

A conference on lunar problems was part of the astronautics symposium held in April at Boulder, Colorado, under U. S. Air Force auspices. At this conference F. L. Whipple discussed the question of roughness of the lunar surface.

The Smithsonian astronomer first summarized the strong evidence that the moon's surface is largely covered by a very thin layer of dust or fine-grained porous material. The fact that the edge of the lunar disk appears practically as bright as its center shows that the surface must be highly irregular on a microscopic scale. Furthermore, measurements of lunar radiation at centimeter wave lengths indicate a very thin covering layer of material, perhaps a millimeter thick, that is an excellent insulator of heat.

The moon's surface is also irregular on a scale of a few meters, as shown by radar-echo studies made in Australia and England. However, it is much smoother over somewhat shorter distances, for with 10-centimeter radar our satellite gives a nearly specular reflection — practically all the echo comes from the central portion of the hemisphere that faces us.

Dr. Whipple proposed that the surface layer may not be loose dust, as T. Gold has suggested (*Sky and Telescope*, March, 1957, page 224), but that the particles are weakly cemented together. Unprotected by any appreciable atmosphere, the moon is continually bombarded by small, high-velocity meteoritic and atomic particles. Thus the dust grains are subjected to a sputtering process, analogous to the action in a high-vacuum aluminizing tank where evaporation takes place from a hot filament. The chemically mixed spray may produce a coating on the grains that acts as a weak cement. Because of this, Dr. Whipple believes, a low-density semi-porous matrix will be formed, fragile compared to normal sedimentary rocks on earth, but strong compared to a layer of dust alone.

Except in the vicinity of craters (including some too small to be observed directly), the lunar surface may therefore be comparatively smooth, although microscopically rough. This is not discordant with the rugged appearance of the moon viewed telescopically, which results mainly from very much larger irregularities having low surface inclinations.

KEIVIN BURNS DIES

On April 30, 1958, Dr. Keivin Burns, an astronomer at Allegheny Observatory of the University of Pittsburgh from 1920 until 1952, died at the age of 77. He had carried on his important laboratory researches on precise wave lengths until three months before his death.

A 1903 graduate of the University of Minnesota, he spent a few years at Lick Observatory measuring 1,600 spectrograms in W. W. Campbell's program on the motion of the sun. He also made spectrographic studies of the Ring nebula, pointing out the value of monochromatic images for revealing details of nebular structure. For his doctor's thesis at the University of Minnesota in 1910, Dr. Burns worked on colors of stars in the Orion nebula.

For photography at the red end of the spectrum, he used dye filters, and in World War I assisted Langley Field aviators in making the first haze-piercing military photographs from airplanes. Other infrared "firsts" were the identification of ionized-calcium lines in the solar-prominence spectrum in 1919, and, at the eclipse of January 24, 1925, the recording of the infrared flash spectrum and the infrared coronal line.

Long lists of laboratory and solar wave lengths of iron and other elements in the *Transactions* of the International Astronomical Union testify to years of painstaking work by Dr. Burns. This phase of his career began with appointment as the first Kellogg fellow at Bonn and Marseilles from 1911 to 1913. He introduced spectrochemical analysis into the United States, and industrial Pittsburgh benefited from his advice when spectrochemical laboratories were springing up in the 1920's. From 1913 through 1919, he was a physicist at the National Bureau of Standards. Shortly before his retirement in 1952, Dr. Burns turned entirely to his wave-length work, with the collaboration of K. B. Adams, Westinghouse Research Laboratories. The latter will complete and prepare for publication the current work on copper II and neon II.

When director H. D. Curtis left Allegheny for Michigan in 1930, he called upon his life-long friend to design the spectroheliokinematograph that was

IN THE CURRENT JOURNALS

A SIMPLE METHOD OF PLOTTING THE TRACK OF AN EARTH SATELLITE, by R. A. Anderson and C. S. L. Keay, *Journal* of the British Interplanetary Society, March-April, 1958. "The method consists of preparing a template which represents the approximate path of the orbit (assumed to be circular) projected on the earth's surface. By means of this, any reports (or authoritative predictions) of the satellite position may be related to the time and longitude at which it crossed the equator (the node of the orbit). From these times an ephemeris may be compiled."

SOME HINTS FOR DOUBLE-STAR OBSERVERS AND ORBIT COMPUTERS, by W. H. van den Bos, *Publications* of the Astronomical Society of the Pacific, April, 1958. "I believe that more nonsense has been written on the subject of the limit of separation of a telescope than on any other subject in double-star astronomy. . . . To agree with observation, Dawes' coefficient . . . should depend on the magnitude, the difference of magnitude, and the light-gathering power of the telescope, not to mention the obvious: the seeing and the observer's acuity of vision."

NEW GIANT RADIO TELESCOPES

At Bigpine, California, in the Owens Valley east of the Sierra Nevadas, twin 90-foot radio telescopes are now being erected by California Institute of Technology. They will move along tracks to form an interferometer system. This picture is of a model of one of the instruments, the largest of their type in the United States. Simplification of mounting design has been achieved by restricting the hour-angle turning of the paraboloid to four hours on each side of the meridian. The instruments and associated equipment were described in the "Griffith Observer," February, 1957, issue.

used in the pioneering solar-prominence motion pictures at the McMath-Hulbert Observatory. It was quite a task to fit the optical parts into a space only 42 by 9 by 6 inches!

Always interested in positional astronomy, Dr. Burns observed regularly with the 30-inch Thaw photographic refractor. He took pictures of planets, satellites, and asteroids for positions, did proper-motion work, and photographed double stars for orbits and masses. He obtained many thousands of the Allegheny parallax plates, and personally measured them to find the distances of 158 stars.

Dr. Burns served as treasurer of the American Astronomical Society from 1941 to 1946.

AMERICAN ASTRONOMICAL SOCIETY

The 100th meeting of the American Astronomical Society was scheduled to be held at the Washburn Observatory, Madison, Wisconsin, June 30th to July 2nd. In addition to the 51 papers during the regular sessions, there is to be a conference on the analysis of composite radiation from stellar systems, on June 30th. That same evening the new Washburn Observatory and its 36-inch reflecting telescope are being dedicated On the following day, Dr. Walter Baade, Mount Wilson and Palomar Observatories, delivers the Russell lecture, on galaxies and stellar evolution.

GIANT SOLAR FURNACE

At Cloudcroft, New Mexico, not far from the Sacramento Peak Observatory, a solar furnace of immense dimensions will be erected for the U. S. Air Force. It will have a paraboloidal focusing mirror 108 feet in diameter, into which sunlight is to be fed by a 750-ton flat mosaic mirror 150 feet wide, mounted on railroad tracks.

The great curved mirror will concentrate 370,000 watts of solar energy into a circle five inches in diameter, achieving a temperature as high as 7,000° centigrade, depending upon the nature of the sample of material under study. The resulting heat can boil tungsten, platinum, and carbon, or punch a hole through any material known today.

An enormous Venetian-blind-type shutter, as high as a 10-story building, will regulate the amount of sunlight reaching the focusing mirror, and it can be opened and closed within half a second of time. This rapid control will aid tests of materials for missiles, manned space craft, and nuclear reactors, for the armed forces, government agencies, and private industry.

J. W. Fecker, Inc., is responsible for the design and development of all optics and servo controls of the solar furnace, and Pittsburgh-Des Moines Steel Co. is the contractor for the basic supporting structure.

French scientists, on the basis of experience with a 30-foot solar furnace now operating in the Pyrenees Mountains, are building a 60-foot furnace in North Africa. But it is expected that the Fecker mirrors will have greater efficiency, for they will be preformed and not stressed as in the French design.

BRUCE MEDAL

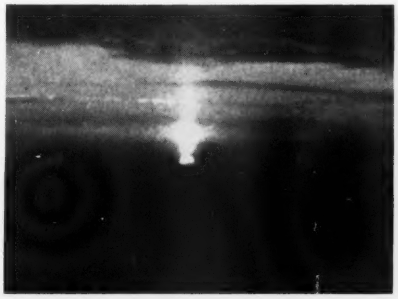
Yerkes astronomer William W. Morgan has received the Bruce gold medal of the Astronomical Society of the Pacific, in recognition of his pioneering studies of stellar spectra and galactic structure during 30 years at the Wisconsin observatory.

Cited in the award were Dr. Morgan's investigations of peculiar *A* stars; his 1943 publication, with P. C. Keenan and Miss E. Kellman, of the *Atlas of Stellar Spectra;* his discovery in 1951, in collaboration with S. L. Sharpless and D. E. Osterbrock, of the existence of separate spiral arms in our galaxy; and his establishment, with H. L. Johnson and D. L. Harris, of a precise system of stellar magnitudes and colors. Dr. Morgan's most recent work has been on the spectra of globular clusters and galaxies.

KNUT LUNDMARK

An outstanding Swedish astronomer, Knut Lundmark, who was director of Lund University Observatory for many years, died on April 25, 1958. He was a prolific author with wide-ranging interests, his favorite subjects being galaxies and the history of astronomy.

Dr. Lundmark made many contributions to the problem of the distances of galaxies, and was the first to demonstrate the existence of supernovae as a class distinct from ordinary novae. At the time of his death he was a member of four commissions of the International Astronomical Union.



SUN PILLAR

This picture shows a sun pillar — a brilliant streak above the sun, with a fainter counterpart below. Walter A. Feibelman of Pittsburgh, Pennsylvania, took the photograph one afternoon last February at about 5:35 p.m. The pillar was first noticed at 5 o'clock, and persisted for about 20 minutes after sunset.

M. Minnaert in *Light and Colour in the Open Air* describes this phenomenon, which is due to reflections from the horizontal faces of ice crystals in the air. It is fairly often seen near sunrise or sunset, especially in winter.

QUESTIONS... FROM THE S+T MAILBAG

Q. What is a *spider?*

A. Any support system for optical elements that is in the light path of a telescope. One example is the spider that holds the flat secondary mirror or prism in a Newtonian reflector. Usually made of four straight vanes, a spider may have three vanes, or consist of circles.

Q. What is the range of variability of Polaris?

A. Only 0.09 magnitude visually; at shorter wave lengths the amplitude is greater.

Q. What are the vertical and horizontal lines on the planet chart in Celestial Calendar each month (page 481 of this issue)?

A. The vertical lines mark right ascension, which in the sky corresponds to longitude on the earth; R. A. is measured eastward from the March or vernal equinox point of the celestial sphere. The horizontal lines are of declination, analogous to terrestrial latitude.

Q. How bright would the sun appear as seen from the star Capella, and where would it be located in the sky?

A. The sun would be of apparent visual magnitude +5.6, in the northern part of the constellation Ara.

Q. Do meteoritic fragments from the Barringer Crater in Arizona show Widmanstätten figures when etched?

A. Only a very small percentage do, according to John S. Rinehart of the Smithsonian Astrophysical Observatory.

Q. What does it mean to say that a telescope has a resolution of 1.1 seconds of arc?

A. This means that the telescope will show as a double two stars that are only 1.1 seconds of arc apart on the sky.

Q. What is the purpose of setting circles?

A. These are placed on the axes of an equatorially mounted telescope to permit pointing directly at a celestial body whose right ascension and declination are known. These co-ordinates may be obtained from an almanac or star catalogue, but the local sidereal time must also be known. Circles should be accurate enough to put the object into the field of a low-power eyepiece.

Q. What is the highest magnification successfully used in visual observing?

A. Experienced double star observers, on very rare occasions, have used powers as high as 3,000 with the 36-inch Lick Observatory refractor. For most ordinary purposes, however, amateurs will not find useful any power greater than about 50 per inch of aperture, for example, 200x on a 4-inch telescope. W. E. S.

OBSERVING THE SATELLITES

Sputnik III Launched

ANOTHER automatic laboratory for cosmic and geophysical observations, larger than any of its predecessors, was launched into orbit sometime earlier than 9:00 Universal time on May 15th by Russian technologists, who named it Sputnik III. Simultaneously the final-stage rocket carrier began to orbit, as did three parts that had protected the satellite during the early stages of launching.

The rocket carrier is by far the largest and brightest artificial object now revolving around the earth. Among scientists it is known as $1958\delta 1$, while the instrumented satellite is $1958\delta 2$. In the days immediately after launching, two fainter objects were also observed. Designated $1958\delta 3$ and $1958\delta 4$, they are probably the tapered semicylindrical cone parts shown in the diagram below. Observations of the nose cone have not yet been reported.

The most impressive part of the Soviet launching announcement was the stated great size and weight of the instrument package — $11\frac{2}{3}$ by $5\frac{2}{3}$ feet and 2,925 pounds in all. There is a 2,133-pound payload of apparatus and batteries. In comparison, the total mass of Sputnik I was 184 pounds, and Sputnik II's payload was given as 1,118 pounds. (The latter satellite was not separated from its rocket carrier; its total weight, though unannounced, may well have exceeded that of Sputnik III.) Current information about sizes and orbits is given in the accompanying table, which compares Sputnik III with the three American satellites launched this year from Cape Canaveral, Florida.

As with Sputniks I and II, the orbit plane of III is inclined about 65° to the earth's equator, which brings the newest objects within visibility for most of the inhabited regions of the world. During favorable crossings, the rocket carrier reaches about 2nd magnitude for brief flashes, but between these brightenings, which occur at about seven-second intervals, it fades several magnitudes due to rotation. The satellite itself also fluctuates rapidly in brilliance, the peaks averaging 5th magnitude during typical crossings.

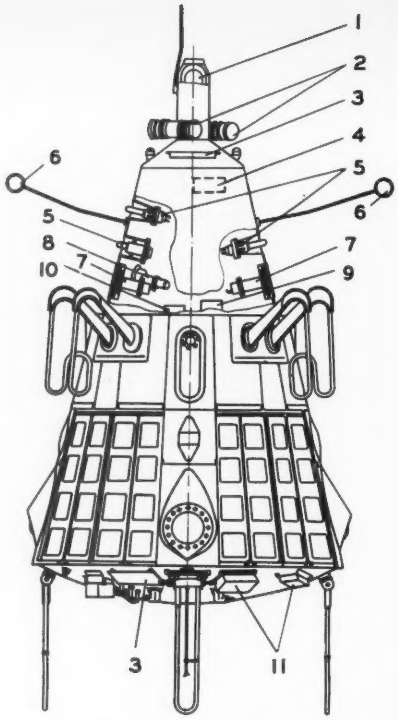
With perigees initially about 130 miles above the earth's surface, both $\delta 1$ and $\delta 2$ are subject to considerable atmospheric friction, tending to reduce their apogee distances and shorten their periods. These orbital changes are more rapid for the rocket than the satellite, because of the larger surface of the former in proportion to its mass. It is predicted that by early July the rocket will have made three more circuits than the satellite.

Instrumentation of Sputnik III

THE RUSSIANS describe their new satellite as a space station designed for automatic, diversified observations. Data obtained by several types of apparatus are being stored in memory systems and, when the satellite passes over a recording station, are telemetered to the ground through several simultaneous radio channels.

In a cosmic-ray program more elaborate than any previously attempted in space, Sputnik III is measuring the spectrum of energy distribution of cosmic rays and their variation with altitude and latitude. It is attempting to detect gamma rays in the primary cosmic radiation, as well as nuclei of elements heavier than iron. Other equipment is measuring solar X-rays and corpuscular streams from the sun. The evaluation of these observations will require knowledge of the location of the satellite and its orientation in space.

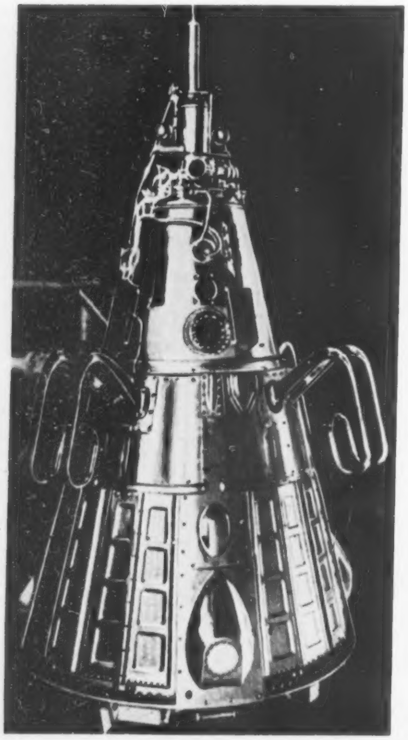
Since solar corpuscles and cosmic rays are much influenced by magnetic fields, the latter are also being studied. From an extended series of satellite observations, it is planned to determine the spatial distribution of the geomagnetic field, and also to measure the magnetic disturbances caused by electrical current systems in the ionized layers of the atmosphere.



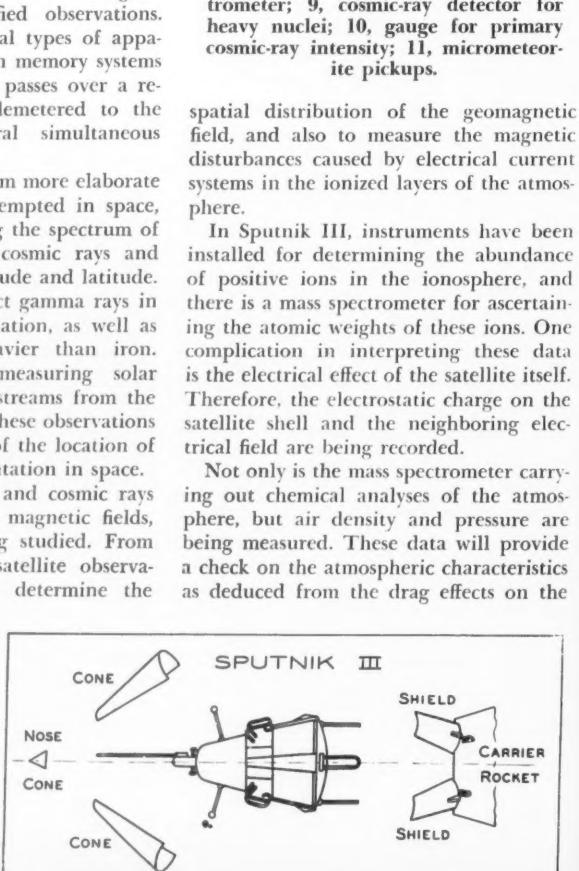
Instruments in Sputnik III: 1, magnetometer; 2, photomultipliers; 3, solar batteries; 4, cosmic-ray photon detector; 5, pressure gauges; 6, ion catchers; 7, electrostatic fluxmeter; 8, mass spectrometer; 9, cosmic-ray detector for heavy nuclei; 10, gauge for primary cosmic-ray intensity; 11, micrometeorite pickups.

In Sputnik III, instruments have been installed for determining the abundance of positive ions in the ionosphere, and there is a mass spectrometer for ascertaining the atomic weights of these ions. One complication in interpreting these data is the electrical effect of the satellite itself. Therefore, the electrostatic charge on the satellite shell and the neighboring electrical field are being recorded.

Not only is the mass spectrometer carrying out chemical analyses of the atmosphere, but air density and pressure are being measured. These data will provide a check on the atmospheric characteristics as deduced from the drag effects on the



Sputnik III, at left, was accompanied in orbit by the other bodies shown in the sketch at the right. Pictures on this page are courtesy U. S. S. R. Embassy, Washington, D. C.



orbital motion. As with earlier satellites, while Sputnik III circles the earth it is recording the impacts of micrometeorites.

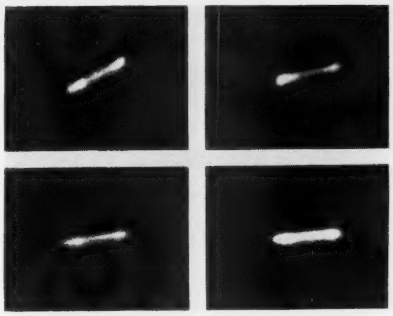
According to the Russian statements, heat-sensing devices not only measure the surface and interior temperatures of the satellite, but insure that the instruments are at the temperature required for normal operation. This regulation is provided by devices controlling radiation and reflection from the satellite skin.

Most of this varied equipment is powered by chemical batteries, but solar batteries are also included. Transistors are extensively used, several thousand of them. (For comparison, a typical portable radio has six.) The electronic timer controlling the automatic programing of all the experiments is entirely transistorized.

Dimensions of Sputnik II

WHILE Soviet spokesmen are providing extensive information about the instrumentation of their satellites, they have released very little data about launching mechanisms. In particular, they have announced nothing concerning the sizes of the final rocket stages that accompanied the Sputniks into orbit. Therefore, a recent report of measurements made at Patrick Air Force Base, Florida, provides significant data.

On December 21, 1957, a crossing of Sputnik II was photographed with an Air Force recording optical-tracking instrument (ROTI) at Melbourne Beach, Florida, by RCA Service Co. personnel. Measurements of image size, after suitable correction for distance and foreshortening, give 79 ± 5 feet as the over-all length of the rocket carrier. The diameter could not be determined, since any reflecting cylinder merely looks like a bright line. Douglas Duke and Stanley J. Macko have interpreted the "glints," seen in photographs like those shown here, as due to the "sphere and dog capsule at one end, and control vanes at the center and other end."



Four of the ROTI photographs, taken December 21, 1957, from which the length of Sputnik II's carrier rocket was deduced. Courtesy of the Perkin-Elmer Corporation.

The ROTI camera that took these photographs is a tracking telescope of 24-inch aperture. Its focal length, which is variable, had its maximum value of 500 inches for these exposures. Another camera of 240-inch focus, 14 miles away, provided means for triangulating the rocket's position.

Lifetimes of American Satellites

EXPLORER III was expected to fall before the end of June, according to the Smithsonian Astrophysical Observatory. Explorer I, because of its greater initial perigee height, will remain aloft until late 1962 (see page 398, June issue).

The lifetime of Vanguard I is of the order of 200 years, according to provisional estimates, and its carrier rocket may last 30 years. The latter object, 1958β1, was declared lost by MOONWATCH headquarters on May 19th, because the few possible sightings reported for it were mutually inconsistent.

It is moving in nearly the same orbit as 1958β2, but with a different period. According to the Naval Research Laboratory, at the instant Vanguard I was separated mechanically from its rocket carrier, their relative velocity was 0.95 feet per second. Presumably this velocity was along the line of flight, which would mean a difference in period of about one second per revolution. Subsequently, atmospheric drag would further separate the rocket from the radio-carrying satellite.

Satellite Publication

MORE than 150 pages of data on the first two Sputniks have recently been published as Vol. 2, No. 10, of *Smithsonian Contributions to Astrophysics*. This publication gives orbital characteristics and long lists of observations of 1957α and 1957β, reprints of Soviet data, and preliminary analyses of upper atmosphere densities. It may be obtained from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., for $1.00.

MARSHALL MELIN
Research Station for Satellite Observation
Operation MOONWATCH
Cambridge 38, Mass.

CHARACTERISTICS OF 1958'S SATELLITES*

SATELLITE	1958 α	1958 β 1	1958 β 2	1958 γ	1958 δ 1	1958 δ 2
Name	Explorer I	Rocket	Vanguard I	Explorer III	Rocket	Sputnik III
Launching date	February 1	March 17	March 17	March 26	May 15	May 15
Launching time (UT)	03:48	12:15:41	12:15:41	17:38:04	Before 9^h?	Before 9^h?
DESCRIPTION						
Shape	Cylinder	Cylinder	Sphere	Cylinder	Cylinder	Cone
Length (inches)	80	57	(6.4)	80	?	140
Diameter (inches)	6	18	6.4	6	?	68
Weight (pounds)	31	51	3.2	31	?	2925
Payload weight (pounds)	18	None	(2.2)	18?	None	2135
INITIAL ORBIT						
Inclination (degrees)	33.14	34.30	34.30	33.5	64.9	64.9
Period (minutes) a = anomalistic, n = nodal	114.95a	134.29a	134.29a	115.91a	105.82n	105.82n
Perigee (miles above earth)	229	405	405	117	123	123
Apogee (miles above earth)	1578	2463	2463	1740	1160	1160
ORBIT SITUATION ON JUNE 5th, 0^h UT						
Longitude of ascending node (degrees west)	73	Lost	339	330	293	292
Nodal period (minutes)	113.87		134.11	99.47	104.95	105.7
Rate of change of period (minutes per day)	-0.007		-0.0003	-0.27	-0.046	-0.013
Apogee (miles above earth)	1534		2463	780	1118	1154
Rate of change of apogee (miles per day)	-0.4		-0.015	-16	-2.7	-0.8
Height over 30° north latitude (miles)						
South-to-north crossing	1197		842	778	155	155
North-to-south crossing	641		418	642	590	600
Number of revolutions completed	1559		851	940	283	282

*Adapted in part from G. F. Schilling's table (in *Special Report* No. 12, Smithsonian Optical Satellite Tracking Program), from other data provided by the Smithsonian, and from Russian press releases. Many of the listed values are estimated; sometimes the last two digits are uncertain.

WAR-SURPLUS AMERICAN-MADE
7 X 50 BINOCULARS

Brand new — these will cost you more than do Japanese binoculars but the quality is much better. They are more rugged, and because of durability will be far cheaper in the end. Excellent night glass. This is the size recommended for satellite viewing. Individual eye focus. Exit pupil 7 mm., approx. field at 1,000 yards is 376 feet. 7-power objective lenses, 50-mm. (2") diameter. Carrying case included. Each optical element coated. American 7 x 50's normally cost $195.00, and our war-surplus price saves you real money.

Stock #1533-Y.......................................$55.00 ppd.
(Tax Included)

TRIPOD CARRYING STRAP

Government had these made to go around tripod for easy carrying. You can also use to carry telescopes, movie screens, and the like.

Stock #60,063-Y. . Extra-heavy-duty removable straps — hold tripod from 3" to 5½" diameter.....**$2.00 ppd.**

Stock #60,064-Y. . One-piece construction — holds tripod from 5" to 6½" diameter..........**$1.00 ppd.**

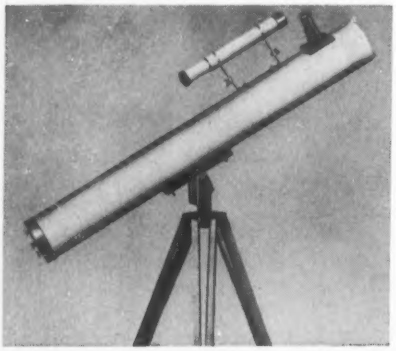
SATELLITE TELESCOPE

Especially made for members of MOONWATCH. Gives you the greatest possible field with the ability to observe faint objects with only slight magnification. Wide (51-mm.) diameter, low-reflection-coated objective lens. A 6-element, extremely wide-field, coated Erfle eyepiece, which in combination with the objective, gives 5.5 power with a big 12° field and over 7-mm. exit pupil. This scope also makes a perfect wide-field finder — a wonderful comet seeker; see complete asterisms.

Stock #70,074-Y.......................................$49.50 ppd.

3" ASTRONOMICAL REFLECTOR

60 to 160 Power — An Unusual Buy!



Assembled — ready to use! See Saturn's rings, the planet Mars, huge craters on the moon, star clusters, moons of Jupiter, double stars, nebulae, and galaxies! Equatorial-type mounting with lock on both axes. Aluminized and over-coated 3"-diameter f/10 primary mirror, ventilated cell. Telescope comes equipped with a 60X eyepiece and a mounted Barlow lens, giving you 60 to 160 power. A finder telescope, always so essential, included. Sturdy, hardwood, portable tripod.

Free with scope: Valuable STAR CHART and 272-page ASTRONOMY BOOK.

Stock #85,050-Y...................................$29.50 f.o.b.
(Shipping wt. 10 lbs.) Barrington, N. J.

TWIN-RING FINDER MOUNT

Unit is all in one piece for easy mounting on tubes of any size. Each ring has an inside diameter of 2⅞". Over-all length 6½", 5" high. 3 adjusting screws on each ring to align your finder scope with your telescope. Made of cast aluminum, black-wrinkle finish.

Stock #70,079-Y..........................$9.95 ppd.

LARGE RIGHT-ANGLE PRISM

This is the first time we have been able to offer a fine large right-angle prism. Gov't. cost $69.00, made by Graflex for K-25 aerial camera. Prism is in a metal mount with 43-mm.-diameter hole; can easily be removed. Faces are 2-7/16" x 2-7/16". Silvered, flat to about 3 wave lengths, comes in nice wooden box.

Stock #50,172-Y..........................$9.50 ppd.

"TIME IN ASTRONOMY" BOOKLET

By Sam Brown. All about various kinds of time, contains sidereal timetable. How to use single- and double-index setting circles, how to adjust an equatorial mount, list of sky objects. Also includes 7" paper setting circles and stripes suitable for cutting out and mounting on plywood. Wonderfully illustrated.

Stock #9054-Y..............................60c ppd.

DOVE PRISMS

Stock #3028-Y.... Entrance and exit faces 18 mm. x 25 mm., length 75 mm.................**$1.50 ppd.**

Stock #3300-Y.... Entrance and exit faces 27 mm. x 37 mm., length 114 mm................**$9.00 ppd.**

QUARTZ CRYSTALS

Rejected by an electronics manufacturer for not having correct electrical axes. Rough average size, 2" x 1¼" x 1¼". Package contains 2 pieces.

Stock #40,135-Y....Per package..........$1.00 ppd.

OBSERVE SUNSPOTS

There are more sunspots now than for many a year. Join the International Geophysical Year effort of research on the sun. It's fun to use your telescope during broad daylight. Care must be taken to avoid damage to your eyes.

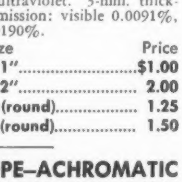
There are several methods of reducing intensity of the sun's rays, but the most popular is using a Herschel wedge plus a sun filter over the eyepiece.

UNMOUNTED HERSCHEL WEDGE

Size, 40 mm. x 55 mm.; wedge angle is 10°. The critical surface is flat to ¼ wave. Not mounted.

Stock #30,265-Y...$3.50

MOUNTED HERSCHEL WEDGE



Same size as above but mounted with diagonal holder for reflectors. Fits our rack-and-pinion holder, Stock No. 50,077-Y, that is also used on our 4¼" and 6" reflectors. Holder rod is long enough for 4¼", 6", and 8" mirrors. Rod is 5/32" diameter and 5" long.

Stock #30,266-Y....$5.50

SUN FILTERS

These filters help protect the eyes from normal visible rays, invisible infrared and ultraviolet. 3-mm. thickness. Per cent of light transmission: visible 0.0091%, ultraviolet none, infrared 0.0190%.

Stock No.	Size	Price
2726-Y	**1" x 1"**	**$1.00**
2727-Y	**2" x 2"**	**2.00**
2728-Y	**⅞" (round)**	**1.25**
2729-Y	**1¼" (round)**	**1.50**

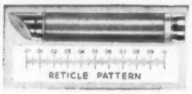
7X FINDER TELESCOPE–ACHROMATIC

Stock #50,080-Y Finder alone, less ring mounts...$9.95
Stock #50,075-Y Ring mounts per pair..........$3.95

INVITATION

VISIT OUR RETAIL STORE — (10 miles from Philadelphia — two miles from Exit #3 of the New Jersey Turnpike). When you're near us, stop in and see our big display. Our store contains many miscellaneous items at bargain prices.

50X MEASURING POCKET MICROSCOPE



Here is a handy little pocket instrument no longer than an ordinary fountain pen. Ideal for measuring and examining objects under 50X magnification. Reticle calibrated for measuring 1/10" by 0.001" divisions. Estimates to 0.0005" can easily be made. We check each one for accuracy before shipping. You make direct readings from reticle — no calculations necessary.

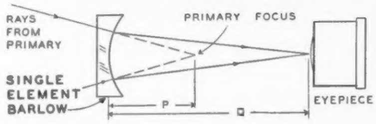
USE THIS MICROSCOPE FOR:

1. Glass surface inspection in mirror grinding and polishing.
2. Abrasive particle size determination and inspection.
3. Checking and measuring small parts for quality control.

Chrome reflector at base of instrument reflects light on objects being examined or measured.

Stock #30,225-Y.......................................$7.95 ppd.

DOUBLE AND TRIPLE YOUR TELESCOPE'S POWER WITH A BARLOW LENS



WHAT IS A BARLOW? A Barlow lens is a negative lens used to increase the power of a telescope without resorting to short focal length eyepieces, and without the need for long, cumbersome telescope tubes. Referring to the diagram above, a Barlow is placed the distance P inside the primary focus of the mirror or objective. The Barlow diverges the beam to a distance Q. This focus is observed with the eyepiece in the usual manner. Thus, a Barlow may be mounted in the same tube that holds the eyepiece, making it very easy to achieve the extra power. The new power of the telescope is not, as you might suppose, due to the extra focal length given the objective by the difference between P and Q. It is defined as the original power of the telescope times the quotient of P divided into Q.

Beautiful chrome mount. We now have our Barlow lens mounted in chrome-plated brass tubing with special spacer rings that enable you to vary easily the power by sliding split rings out one end and placing them in other end. Comes to you ready to use. Just slide our mounted lens into your 1¼" I.D. tubing, then slide your 1¼" O.D. eyepieces into our chrome-plated tubing. Two pieces provided, one for regular focal length eyepieces and one for short focal length ones.

Remember, in addition to doubling and tripling your power, a Barlow lens increases your eye relief and makes using a short focal length eyepiece easier.

Don't fail to try one of these. Many people do not realize the many advantages of a Barlow and the much greater use they can get from their telescopes. Our Barlow has a focal length of −1-5/16". We have received many complimentary letters about this lens. So sure are we that you will like it that we sell it under a 30-day guarantee of satisfaction or your full purchase price returned — no questions asked. You can't lose, so order today.

Stock #30,200-Y Mounted Barlow lens......$8.00 ppd.

WAR-SURPLUS TELESCOPE EYEPIECE

Mounted Kellner Eyepiece, Type 3. 2 achromats, focal length 28 mm., eye relief 22 mm. An extension added, O.D. 1¼", standard for most types of telescopes. Gov't. cost $26.50.

Stock #5223-Y......$7.95 ppd.

EDMUND SCIENTIFIC CO.

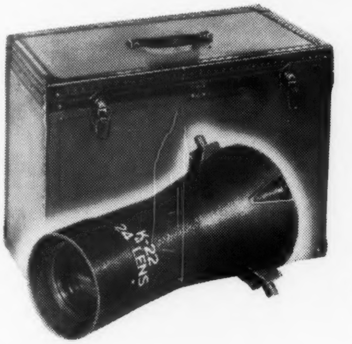
Sale! Terrific Bargains!

WAR-SURPLUS AERIAL CAMERA LENSES

24" Focal Length, f/6, in 23"-long Lens Cone

Made by Bausch & Lomb and Eastman Kodak

$39.50, Used; $59.00, New; Gov't. Cost $1,218.00



Here is a once-in-a-lifetime bargain opportunity in aerial camera lenses. Made by famous manufacturers for the Government and now no longer needed. These lenses are precision-mounted in the lens cone that was attached to the film-carrying part of the camera. Picture size was 9" by 9". The diaphragm is included, adjustable from f/6 to f/22 by a flexible rod (easily extended) near camera end of the cone. Diaphragm opens from about 1" to 3½".

Focal plane of lens is about 10" outside the end of the cone, making it easy to attach film holder, eyepiece, or the like. These 4"-diameter lenses are precision 4-element types, Aero Tessar or Aero Ektar (no choice), weighing 25 lbs. with cone. Fine trunklike carrying case weighs 26 lbs. Lens elements are in beautiful brass cells which screw into the diaphragm holder. Cell can be easily taken out of cone in a few minutes.

USES:

1. As a long-range, Big Bertha telephoto lens.
2. For visual richest-field telescope objective (wide field, low power) with one of our wide-field Erfle eyepieces. Not recommended for use above 24X unless stopped down to f/11. Use to see satellites, star clusters, star fields, and more.
3. As an opaque-projector lens.
4. For operation PHOTOTRACK.

SALE AERIAL CAMERA LENSES

Lens Cones with f/6 24" focal length —

Stock #85,059-Y....24", Used......$39.50 f.o.b. Utah

Stock #85,060-Y....24", New......$59.50 f.o.b. Utah

OPERATION PHOTOTRACK

The Society of Photographic Scientists and Engineers is co-operating with the Smithsonian Astrophysical Observatory and the International Geophysical Year national committee in operation PHOTOTRACK — a project in which technically minded photographers are asked to aid in photographing the artificial satellites. For information, write to the society's secretary-treasurer, Norton Goodwin, 826 Connecticut Ave. N.W., Washington 6, D. C.

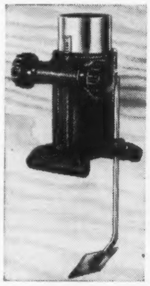
ALSO AVAILABLE

Lens Cones with f/8 40" focal length —

Stock #85,061-Y......Used...........$68.50 f.o.b. Utah

Stock #85,062-Y......New...........$89.50 f.o.b. Utah

Rack & Pinion Eyepiece Mounts



For Reflectors

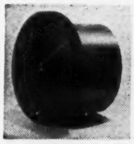
For Refractors

Now you can improve performance in a most important part of your telescope — the eyepiece holder. Smooth, trouble-free focusing will help you to get professional performance. Look at all these fine features: real rack-and-pinion focusing with variable tension adjustment; tube accommodates standard 1¼" eyepieces and accessory equipment; lightweight aluminum body casting; focusing tube and rack of chrome-plated brass; body finished in black wrinkle paint. No. 50,077-Y is for reflecting telescopes, has focus travel of over 2", and is made to fit any diameter or type tubing by attaching through small holes in the base. Nos. 50,103-Y and 50,108-Y are for refractors and have focus travel of over 4". Will fit our 2⅞" I.D. and our 3⅞" I.D. aluminum tubes respectively.

Stock #50,077-Y (less diagonal holder) $9.95 ppd.
Stock #60,035-Y (diagonal holder only) 1.00 ppd.
Stock #50,103-Y (for 2⅞" I.D. tubing) 12.95 ppd.
Stock #50,108-Y (for 3⅞" I.D. tubing) 13.95 ppd.

Mounted Ramsden Eyepieces

Standard 1¼" Diameter



Our economy model, standard-size (1¼" O.D.) eyepiece. We mounted two excellent quality plano-convex lenses in black anodized aluminum barrels instead of chrome-plated brass to save you money. The clear image you get with these will surprise you. Directions for using short focal length eyepieces are included with both the ¼" and ½" models.

Stock #30,204-Y....¼" focal length....$4.75 ppd.
Stock #30,203-Y....½" focal length....$4.50 ppd.

PRISM STAR DIAGONAL

For comfortable viewing of the stars near the zenith or high overhead with refracting telescopes using standard size (1¼" O.D.) eyepieces, or you can make an adapter for substandard refractors. Contains an excellent quality aluminized right-angle prism. Tubes are satin chrome-plated brass. Body is black wrinkle cast aluminum. Optical path of the system is about 3½".

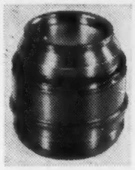
Stock #70,077-Y..................................$12.00 ppd.

"MAKE-YOUR-OWN" 4¼" MIRROR KIT

The same fine mirror as used in our telescopes, polished and aluminized, lenses for eyepieces, and diagonal. No metal parts.

Stock #50,074-Y..................................$16.25 ppd.

Sale! GIANT ERFLE EYEPIECE



Wow! Here is a real bargain. We just bought a large lot of these eyepieces reasonably — so down goes the price to $9.95 for a real sale. Lens system contains 3 coated achromats over 2" in diameter. Gov't. cost over $100.00. Brand new, weight 2 pounds. The value will double when this sale is over, and triple and quadruple as years pass. If we didn't owe the bank so much money, we'd be tempted to hold onto these eyepieces. They give you a wide field of 65°. The focal length is 1½". Lenses are in a metal cell with spiral threads; focusing adapter with 32 threads per inch is included; diameter is 2-11/16". If you don't order now and you miss out on a hundred-dollar eyepiece for only $9.95, you can't say that we didn't try to impress you with its value. You can make some super-duper finders with these eyepieces. They are also ideal for richest-field telescopes, which are becoming popular each day, particularly in the Sputnik age. Everyone with a large reflecting telescope should have one of these.

Stock #50,178-Y.................Sale Price $9.95 ppd.

3X ELBOW TELESCOPE

Sometimes the war-surplus end of this business is heartbreaking. Here is an excellent little telescope that cost Uncle Sam about $200.00. Makes a dandy finder with a 13° field. Weight 2 pounds, size 5¾" x 4½". Although our price has been only $7.50 postpaid, they just sit on our shelves year after year. Then to get an item we really wanted, we had to buy 200 more of these telescopes recently. Objective lens is an achromat, diameter 26 mm., focal length 104 mm. Amici roof prism with faces of 18 mm. x 20 mm. cost from $12.00 to $36.00 to make. Symmetrical eyepiece of 1¼" (32.5 mm.) effective focal length consists of 2 achromats with diameters of 34 mm. and focal lengths of 65 mm. At our new price we cannot afford to have our instrument man take these apart and clean them — so we told him to look them over to make sure everything is okay, and now you can buy them for only $5.00 each delivered to you.

Stock #50,179-Y....................................$5.00 ppd.

6X FINDER TELESCOPE

Has crosshairs for exact locating. You focus by sliding objective mount in and out. Base fits any diameter tube — an important advantage. Has 3 centering screws for aligning with main telescope. 20-mm.-diameter objective. Weighs less than ½ pound.

Stock #50,121-Y....................................$8.00 ppd.

MISCELLANEOUS ITEMS

KELLNER EYEPIECE — 2" focal length (1¼" O.D.). Mount of black anodized aluminum.

Stock #30,189-Y.........................$6.00 ppd.

60° SPECTROMETER PRISM — Polished surfaces 18-mm. x 30-mm. — flat to ½ wave length.

Stock #30,143-Y.........................$8.25 ppd.

ASTRONOMICAL TELESCOPE TUBING

Stock No.	I.D.	O.D.	Lgth.	Description	Price
80,038-Y	4⅞"	5¼"	46"	Spiral-wound paper	$2.50
85,008-Y	6⅞"	7⅜"	60"		4.00
85,011-Y	2⅞"	3"	48"	Aluminum	6.00
85,012-Y	3⅞"	4"	60"		8.75
85,013-Y	4⅞"	5"	48"		9.00
85,014-Y	6⅞"	7"	60"		15.00

All tubing is shipped f.o.b. Barrington, N. J.

BE SURE TO GET FREE CATALOG "Y"

Fantastic variety — never before have so many lenses, prisms, optical instruments, and components been offered from one source. Positively the greatest assembly of bargains in all America. Imported! War Surplus! Hundreds of other hard-to-get optical items. Write for Free Catalog "Y."

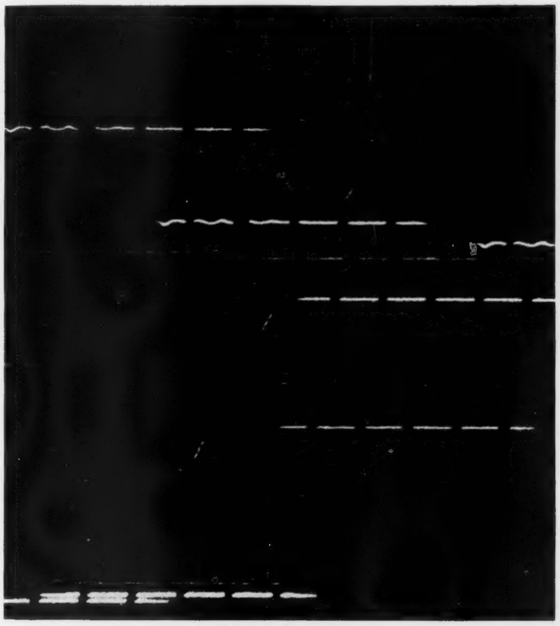
ORDER BY STOCK NUMBER . . . SEND CHECK OR MONEY ORDER . . . SATISFACTION GUARANTEED!

BARRINGTON • NEW JERSEY

SMITHSONIAN ASTROPHYSICAL OBSERVATORY
BULLETIN FOR
Visual Observers of Satellites

NUMBER 9 — 60 GARDEN STREET, CAMBRIDGE 38, MASS. — JULY, 1958

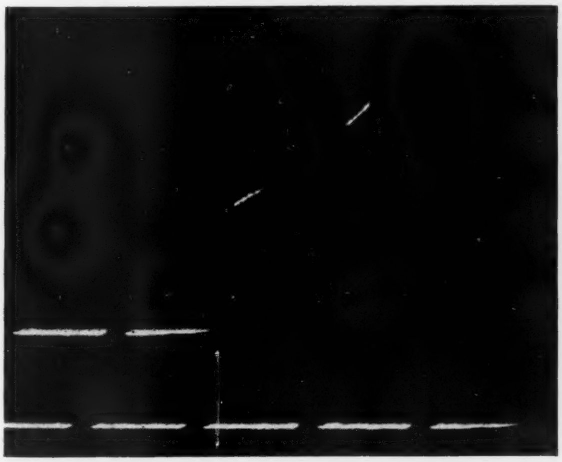
Smithsonian Precision Photographs of 1958's Satellite Rockets



Above: Explorer I (1958α), crossing Lynx on April 11th. The trail segments are separated by eight-second intervals.

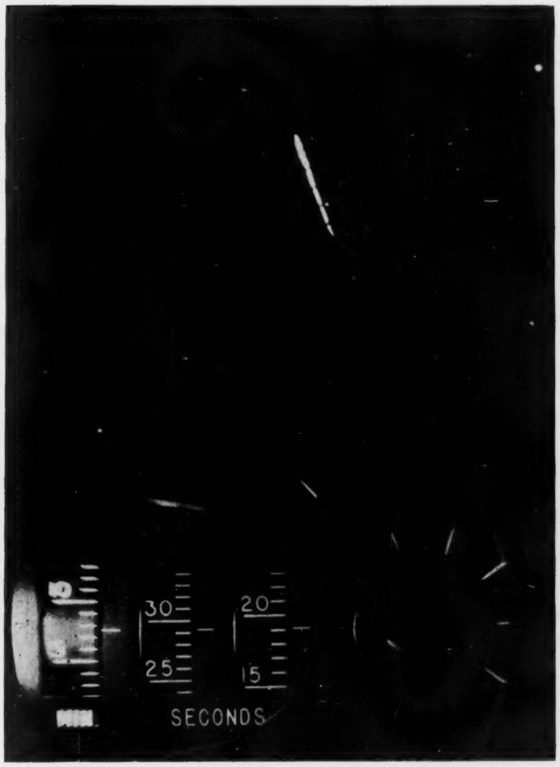
Below: Explorer III (1958γ), in Leo on May 7th.

The pictures of 1958α, γ, and δ on this page were taken with the Baker-Nunn satellite-tracking camera in the Organ Mountains, New Mexico. 1958β was photographed with a Baker Super-Schmidt camera at the same station.



Above: Vanguard I (1958β1), on March 19th, moving eastward from Gamma Bootis (left) past Beta Bootis.

Below: Sputnik III (1958δ1), on May 19th. The bright star in the upper right is Theta Hydrae, and the time reads 3:07:29.1895 UT.



XVI. Regions of Visibility of a Satellite After Launching — II

Geographical areas of morning and evening visibility of United States satellites at the time of their first trips around the world are given below. These tables are similar to the one published in *Bulletin* No. 8, page 4 (March, 1958), and may be used with the distance-elevation chart on the facing page.

However, some changes are incorporated in the new tables: The period is assumed to be 120 minutes rather than 105; the heights are given as 300, 600, and 1,000 miles, rather than 300 and 450; the position of the sun is for May 20th, rather than February 20th. The May 20th values will not change materially until about the 1st of August.

The columns headed "Time in Orbit" refer to when the satellite actually goes into orbit — about 10 minutes after leaving the launching pad. The data were prepared by George Veis of Ohio State University, a consultant on the Smithsonian optical tracking program.

MORNING PERIOD OF VISIBILITY

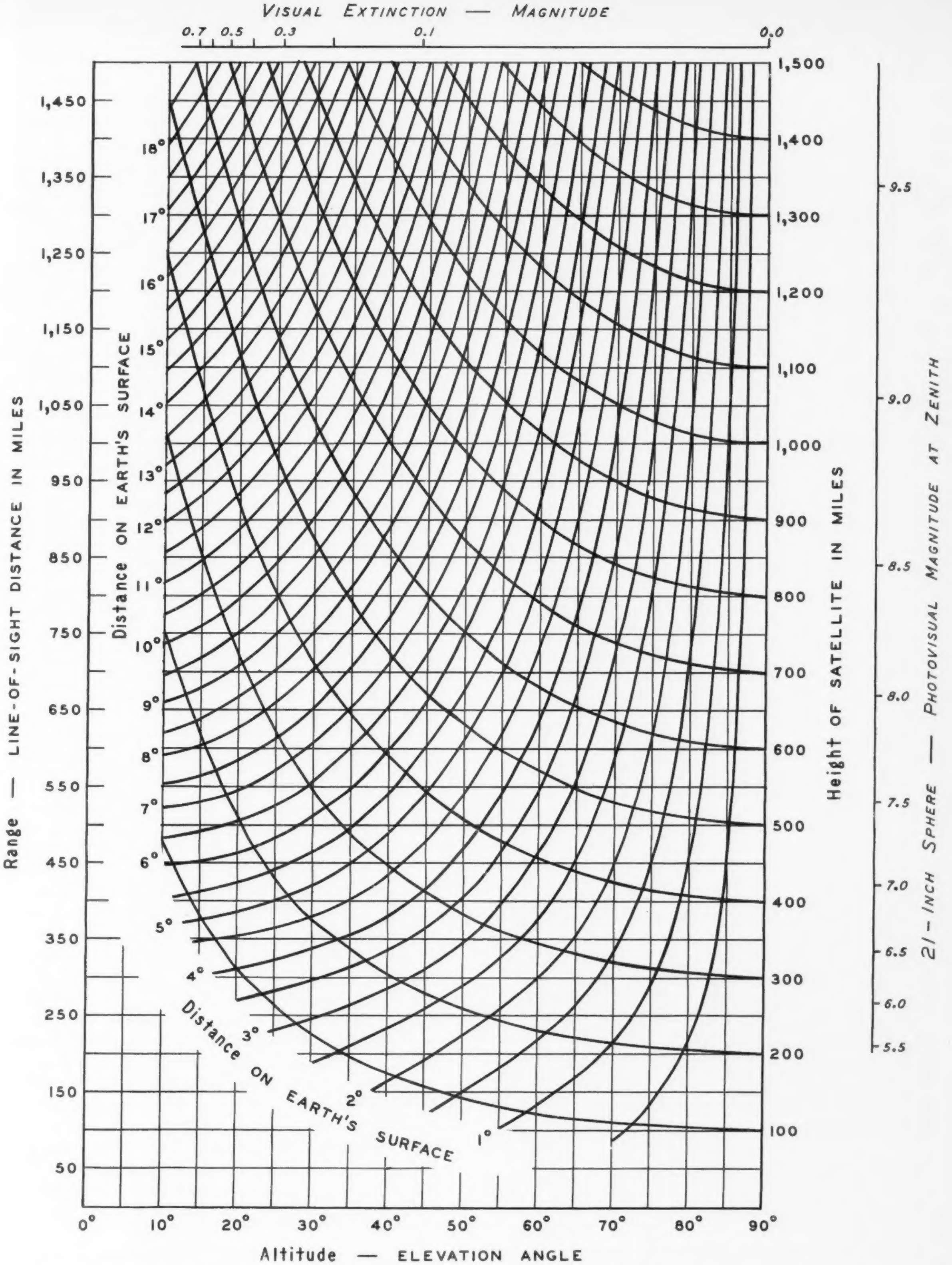
Time In Orbit		First Seen	Inter-val	HEIGHT = 300 Miles		HEIGHT = 600 Miles		HEIGHT = 1000 Miles	
EST	UT	UT	Min.	Latitude Limits	Longitude West*	Latitude Limits	Longitude West*	Latitude Limits	Longitude West*
0	5	5:21	21	35S- 8S	353 - 12	41S- 5N	353 - 27	47S-17N	353- 40
1	6	6:13	13	28S- 3N	9 - 29	34S-17N	9 - 46	40S-34N	9- 61
2	7	7:06	6	15S-17N	28 - 50	21S-34N	28 - 68	27S-51N	28- 95
3	8	9:55	1:55	1S-33N	75 - 97	7S-45N	75 - 123	13S-56N	75-160
4	9	10:50	1:50	11N-41N	95 - 118	5N-50N	95 - 144	1S-58N	95-175
5	10	11:45	1:45	19N-44N	114 - 136	13N-52N	114 - 160	7N-57N	114-181
6	11	12:40	1:40	22N-46N	130 - 152	16N-50N	130 - 172	9N-56N	130-188
7	12	13:36	1:36	23N-46N	144 - 165	14N-52N	144 - 182	6N-58N	144-195
8	13	14:32	1:32	20N-45N	158 - 177	11N-51N	158 - 192	3N-37N	158-203
9	14	15:28	1:28	17N-42N	171 - 188	8N-48N	171 - 201	1S-54N	171-211
10	15	16:25	1:25	13N-39N	182 - 197	3N-45N	182 - 210	6S-51N	182-221
11	16	17:21	1:21	9N-36N	193 - 207	1S-42N	193 - 220	11S-48N	193-230
12	17	18:17	1:17	6N-31N	204 - 218	5S-37N	204 - 230	16S-43N	204-240
13	18	19:12	1:12	3S-24N	215 - 228	14S-30N	215 - 240	26S-36N	215-251
14	19	20:08	1:08	14S-14N	226 - 238	25S-20N	226 - 250	36S-26N	226-261
15	20	21:03	1:03	22S- 5N	236 - 249	33S-11N	236 - 261	42S-17N	236-273
16	21	21:58	58	30S- 2S	247 - 261	40S- 4N	247 - 273	48S-10N	247-285
17	22	22:54	54	36S-10S	251 - 273	45S- 4S	251 - 286	53S- 2N	251-298
18	23	23:49	49	41S-15S	271 - 286	49S- 9S	271 - 300	56S- 3S	271-312
19	1	0:45	45	43S-19S	284 - 299	52S-13S	284 - 313	58S- 7S	284-326
20	2	1:41	41	45S-22S	297 - 313	51S-16S	297 - 327	57S-10S	297-340
21	3	2:37	37	46S-23S	310 - 328	52S-16S	310 - 341	58S- 7S	310-354
22	4	3:32	32	44S-20S	324 - 343	50S-11S	324 - 356	56S- 2S	324- 9
23	5	4:26	26	40S-14S	338 - 357	46S- 5S	338 - 12	52S- 6N	338- 25

*Longitude is expressed as 0° to 360° westward from the Greenwich meridian.

EVENING PERIOD OF VISIBILITY

Time In Orbit		First Seen	Inter-val	HEIGHT = 300 Miles		HEIGHT = 600 Miles		HEIGHT = 1000 Miles	
EST	UT	UT	Min.	Latitude Limits	Longitude West*	Latitude Limits	Longitude West*	Latitude Limits	Longitude West*
0	5	6:36	1:36	23N-46N	139 - 160	16N-51N	118 - 160	9N-57N	105-160
1	6	7:30	1:30	18N-44N	154 - 177	12N-52N	129 - 177	6N-56N	110-177
2	7	8:25	1:25	12N-41N	171 - 194	6N-51N	143 - 194	0 58N	118-194
3	8	9:19	1:19	1N-32N	193 - 213	5S-46N	164 - 213	11S-55N	143-213
4	9	10:10	1:10	12S-19N	211 - 232	18S-37N	188 - 232	24S-49N	172-232
5	10	11:02	1:02	25S- 6N	229 - 248	31S-24N	209 - 248	37S-36N	196-248
6	11	11:56	56	34S- 5S	246 - 264	40S- 9N	229 - 264	46S-22N	216-264
7	12	12:50	50	40S-13S	262 - 279	46S- 2S	248 - 279	52S- 7N	234-279
8	13	13:45	45	44S-19S	277 - 294	50S-11S	265 - 294	56S- 2S	252-294
9	14	14:42	42	46S-23S	292 - 308	52S-15S	280 - 308	58S- 7S	267-308
10	15	15:38	38	46S-22S	306 - 323	51S-17S	294 - 323	57S-10S	282-323
11	16	16:33	33	45S-20S	320 - 336	52S-15S	307 - 336	56S- 9S	296-336
12	17	17:29	29	42S-17S	333 - 348	50S-11S	320 - 348	58S- 5S	309-348
13	18	18:24	24	37S-11S	346 - 1	46S- 5S	333 - 1	54S- 1N	322- 1
14	19	19:19	19	31S- 5S	359 - 13	41S- 1N	346 - 13	50S- 7N	335- 13
15	20	20:15	15	24S- 3N	11 - 25	34S- 9N	358 - 25	44S-15N	347- 25
16	21	21:10	10	17S-11N	22 - 36	27S-17N	10 - 36	37S-23N	359- 36
17	22	22:06	06	8S-20N	33 - 46	18S-26N	21 - 46	29S-32N	11- 46
18	23	23:01	01	0 -28N	43 - 57	11S-34N	32 - 57	21S-40N	21- 57
19	0	1:58	1:58	7N-35N	84 - 96	4S-41N	71 - 96	14S-47N	61- 96
20	1	2:53	1:53	12N-39N	95 - 107	2N-45N	81 - 107	7S-51N	71-107
21	2	3:48	1:48	17N-43N	105 - 119	7N-49N	92 - 119	2S-55N	80-119
22	3	4:44	1:44	20N-45N	115 - 132	11N-51N	100 - 132	3N-57N	89-132
23	4	5:40	1:40	22N-46N	126 - 146	14N-52N	108 - 146	6N-58N	97-146

*Longitude is expressed as 0° to 360° westward from the Greenwich meridian.



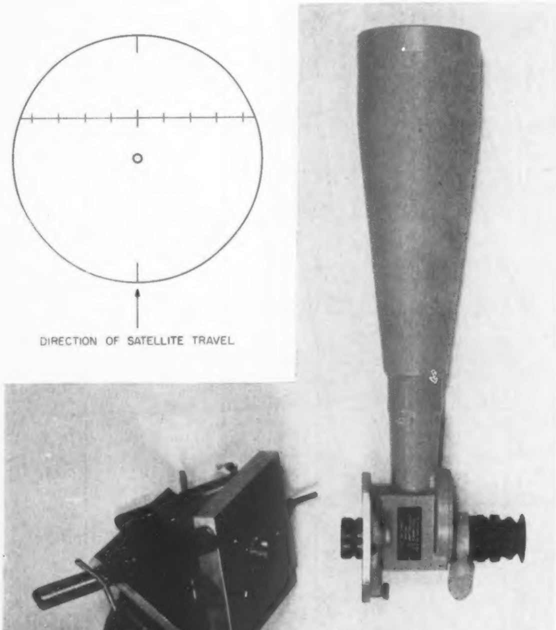
This chart by Jack W. Slowey appeared in Bulletin No. 8, *where instructions were given for finding a satellite's distance and elevation. It may be used in connection with the tables on the opposite page.*

XVII. Apogee MOONWATCH Stations

The need to detect lost satellites, which may be very high and faint, has led to the organization of a network of seven apogee MOONWATCH stations, strategically located and equipped with batteries of special telescopes. Early in 1957, Naval Research Laboratory calculations showed that some Vanguard IGY satellites might rise as high as 2,500 miles, where a 21-inch sphere would be no brighter than 11th magnitude, well beyond the reach of 5½-power standard MOONWATCH telescopes.

We were particularly desirous to insure optical acquisition of a high satellite should its radio transmitter fail to function, so a conference was held at the Smithsonian Astrophysical Observatory on February 23, 1957, to plan the apogee stations. There NRL scientists reported experiments with a precision satellite simulator: The 5½-power instrument could detect satellites as faint as 8th magnitude against a dark nighttime sky; the Army M-17 8-power elbow telescope would reach the 9th magnitude; for very faint satellites a much larger instrument would be required.

The high-power elbow telescope provided by the Navy for the stations is pictured here. It has a magnification of 21½, with an aperture of 120 millimeters, its real field of view being 2¼ degrees. It combines the objective of Navy Mark-I ship's binoculars with the prism and eyepiece unit of the M-17. NRL designed a special reticle (shown in the inset diagram) to assist the observation for time and position.



Special MOONWATCH stations established for observing distant and faint satellites use this high-power telescope designed at the Naval Research Laboratory. The inset diagram shows how the reticle has a reference line that is offset to give the observer more time to recognize a very faint object. The 21½-power instrument can be easily removed from its simple mounting and replaced by an M-17 elbow telescope when low, bright satellites are to be observed. Naval Research Laboratory pictures.

In use, the telescope is aimed so the central circle is on the meridian, and at the desired zenith angle. The crosshair is parallel to the meridian, but offset 0.4 degree in the direction of satellite travel. The simulator experiments had shown that an observer rarely detected a faint object until it was already near the center of the field of view. From then on he could follow it until it left the field. The crosshair displacement allows the observer more time to prepare himself to signal the transit over the crosshair. The latter is illuminated by a controllable faint red light, which does not impair dark adaptation. The small marks are ¼-degree apart on the crosshair, allowing moderately accurate estimates of zenith angle.

Since the 21½x telescope has 2.7 times the aperture of the M-17, it makes equally visible a satellite 2.7^2 times fainter. This corresponds to an object 2.7 times farther away, but this is the same factor by which the 21½x field is narrower than that of the M-17. Therefore the 21½x has about the same lateral coverage in miles as the M-17 has for a satellite 2.7 times closer.

Either instrument may be mounted on a stand of 2½-inch pipe, rigid enough for the purpose. Azimuth is set by rotation on the vertical pipe, with locking screws. The mounting head provides for adjustment to the plane of the meridian and in elevation. An instrument can be quickly removed when the screws on either side of the mounting are loosened.

Locations for apogee stations were chosen to provide maximum coverage of a newly launched satellite from Cape Canaveral, Florida, beginning in South Africa, where skies are usually very clear. Under the direction of Dr. C. G. Hide, secretary of the South African National Council for the IGY, and Dr. David S. Evans, South African MOONWATCH coordinator, stations have been located in Capetown (leader, Dr. Evans), Bloemfontein (leader, G. Walker), Johannesburg and Pretoria (jointly operated under J. Hers). Observers at these stations may see the second pass of an American satellite as well as the first.

For the second group of stations, in the United States, good sky conditions for a planned network over a large area could be found only in the Southwest. These apogee stations are: Kirtland Air Force Base, Albuquerque, New Mexico (leader, Capt. Kenneth W. Shaw); Holloman Air Force Base, Alamogordo, New Mexico (leader, E. P. Martz, Jr.); Naval Ordnance Test Station, Inyokern, California (leader, Carroll L. Evans, Jr.); and Vincent Air Force Base, Yuma, Arizona (leader, Capt. M. A. Raab). The Air Force installations were arranged by Col. Owen F. Clarke, head of the Ground Observer Corps.

The Albuquerque and Alamogordo stations are roughly on a north-south line, while Inyokern and Yuma form a similar pair farther to the west. The east-west separa-

tion of the pairs produces a difference in sunset times of about 40 minutes, so one pair or the other will be in a favorable position for a twilight passage of a new satellite. Also, the northern stations are located near the 35° parallel, and can pick up satellites that have greater than the expected inclination of 35 degrees. To the south, coverage is well below the Mexican border, the Yuma and Alamogordo stations being able to detect a 20-inch Vanguard sphere 2,000 miles high passing over a point as much as 1,000 miles south of them.

A fully instrumented U. S. apogee station has 37 telescope mounts, 37 8x telescopes, and a like number of 21½x instruments, to be used on the same mounts. The 8x telescopes are set 2½ degrees apart along the meridian, down to 45 degrees on either side of the zenith. Since the field of each instrument is six degrees, two observers or sometimes three should see a satellite simultaneously, minimizing the chance of a false report. In the high-power array, the 21½x instruments are pointed one degree apart, so their fields of 2½ degrees overlap considerably.

In looking for a lost satellite whose position is completely unknown, the plan for observing from the American apogee stations during evening twilight is first to use the 8x telescopes, commencing with the sun five degrees below the horizon and the sky dark enough to see a bright, and therefore low, object. The wide field of the 8x instruments will give the large meridian coverage needed for low satellites.

Each station will watch for about an hour, the western pair beginning about 40 minutes after the eastern one, the total observing time being about 100 minutes. This is roughly long enough for a satellite to travel from the eastern stations around the earth to the western stations, where a low satellite would still be sunlit. For longer revolution periods, the observing time may be lengthened by special techniques, such as tilting the meridian array in the direction of the sun for part of the time.

If the satellite is not detected by either pair of stations, it will be assumed to be too high for the 8x telescopes, and 21½x instruments will be placed on the mounts instead. By this time the sky will have reached its full nighttime darkness, but there will be at least 100 minutes during which a high satellite could be sunlit for some part of the network. For observing during morning twilight the plan would be reversed, and low-power instruments will replace the 21½x as the sky changes from full night to twilight.

The South African stations are not arranged in a network, but their considerable north-south separation provides a wide observation fan for coverage of all predicted satellite orbits. These stations are so located that for four months of the South African summer satellites are sunlit all night over some part of the fan.

Even though experience has shown that failure of radio transmitters upon launching is one of the less likely hazards connected with satellites, visual observations have made it possible to determine orbits for those several objects that have not carried radios, and which, therefore, have had to be acquired and tracked primarily by visual observations. The apogee stations are especially well equipped to detect faint satellites, and they have already contributed valuable reports of 1958α, β, and γ.

Should an attempt ever be made to make a large satellite invisible by blackening the surface, it is probable that it would be detected by the apogee stations. Black surfaces rarely reflect less than five per cent, which would represent a magnitude loss of about 3, just the gain provided by the high-power telescopes. Thus, a blackened satellite would be as visible with an apogee telescope as a highly reflecting object of the same size and height is with the standard MOONWATCH 5½x telescope.

ALBERT BOGGESS III, IRENE S. GULLEDGE,
MARTIN J. KOOMEN, and RICHARD TOUSEY
Naval Research Laboratory
Washington 25, D. C.

XVIII. Graphs To Aid in Searching for U. S. Satellites

Given the launching time and orbit inclination of a United States satellite — even though its period is only roughly known — it is possible to predict rapidly the approximate angular elevation of the satellite as it crosses the meridian of any station.

Such predictions should greatly improve the chances of detection by teams that cannot scan the entire meridian. If the radio transmitters of a newly launched satellite fail to perform, this method will be particularly useful as an aid to visual recovery.

There are four steps in the procedure:

1. Determine the longitude of the node for the instant when the satellite first crosses the earth's equator.

2. Determine graphically, as a function of time, the difference between the longitude of the node and the observer's geographical longitude.

3. With the table on page 6, find the mean height of the satellite from its estimated period.

4. Determine graphically the angular elevation of the point of meridian crossing, as a function of time.

These steps will now be described in detail.

1. The satellite will first cross the terrestrial equator at a time T_o, about 20 minutes after it leaves the launching pad. The geographical longitude, L_o, of this crossing point (which is the descending node of the orbit) depends on the orbital inclination. Inclinations of 30°, 35°, and 40° correspond to longitudes (counted *eastward* from Greenwich) of 344°, 326°, and 315°, respectively.

N_o, the longitude of the ascending node for time T_o, is equal to $L_o \pm 180°$.

2. The longitude, N, of the ascending node at any

$$1.\quad N = N_0 - (360^\circ.99 + n)(T - T_0)$$

$$2.\quad n = 10^\circ.05\ (P/84.49)^{-7/3} \cos i$$

$$3.\quad H = 3{,}963\ \left[(P/84.49)^{2/3} - 1\right]$$

$$4.\quad \tan A = \tan i \ \sin D$$

$$5.\quad B = \phi - A$$

$$6.\quad \cot h = \frac{(1 + H/r)\sin B}{(1 + H/r)\cos B - 1}$$

The formulae used in Charles Whitney's method for making approximate predictions of artificial satellites are collected here. Consult the text for definitions of the symbols, and for an explanation of the use of these equations in the construction of the graphs below.

later time T is given by Formula 1, in which n is the number of degrees through which the node shifts westward per day. This rate depends upon the orbital inclination, i, and the period, P; it can be computed from Equation 2, an approximation valid for circular orbits, and in which the period is expressed in minutes.

For example, if the inclination is 35°, then periods of 100, 110, 120, and 130 minutes correspond to n values of 5.56°, 4.45°, 3.63°, and 3.01° per day, respectively.

We use Equation 1 to draw a graph giving N for different values of T. Fig. 1 is such a graph, used to aid in the search for Explorer II, whose attempted launching took place on March 5, 1958, at 18:30 Universal time.

Note that this diagram has *two* sets of co-ordinate labels. Those at the left and bottom give N for various values of Universal time. The time scale on the right is like that on the left, but is labeled "Local Mean Time." The top longitude scale is the reverse of the bottom one.

Therefore, the longitude scale on top gives $N(W)$, the longitude of the node counted westward, when used with the UT time scale. When used with the right-hand scale, it gives $D = N(W) - L_s$, where L_s is the west longitude of the observer's station.

Employed in the latter way, the graph tells us the longitude difference between the ascending node and the observer, as a function of his local time.

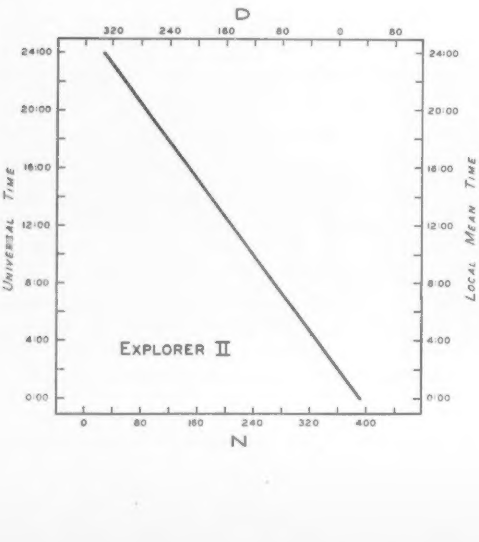
Period (minutes)	*Mean Height* (miles)	*Period* (minutes)	*Mean Height* (miles)
90	170	135	1,454
95	322	140	1,586
100	471	150	1,848
105	618	160	2,103
110	762	170	2,353
115	904	180	2,599
120	1,045	200	3,076
125	1,183	300	5,261
130	1,319	400	7,211

3. For search purposes, we ordinarily must make the simplifying assumption that the satellite is moving in a circular orbit. In this case the height in miles, H, can be computed from the period in minutes, P, by Formula 3, or we can use the table above.

It may be added that for an elliptical orbit the height of the satellite will depend on the eccentricity, semimajor axis, and true anomaly of the point in the orbit being observed. The sum of the perigee and apogee heights is just twice the mean height tabulated here; thus, for example, if we know the period is 115 minutes and the perigee height is 225 miles, then the apogee height is $2 \times 904 - 225 = 1{,}583$ miles. Furthermore,

$$\text{Eccentricity} = \frac{\text{Apogee Height} - \text{Perigee Height}}{\text{Mean Height} + 7{,}926 \text{ miles}}.$$

4. When the orbital height is known, and when D has been computed for the estimated time the observation is to be made, the angular elevation of the orbit on the observer's meridian is determined from a graph like



Two of the graphs drawn in applying Dr. Whitney's method to Explorer II. Fig. 1, left, shows the relationship between position of the node and time. Fig. 2, right, contains curves from which the meridian altitude of the satellite can be predicted. Smithsonian Astrophysical Observatory diagrams.

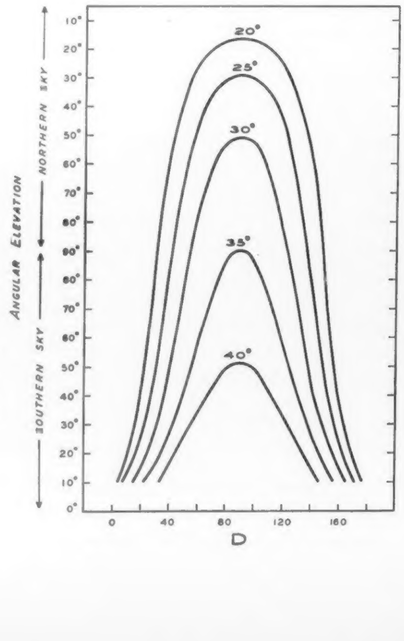


Fig. 2. In this, there are curves for five different geographical latitudes. The horizontal line for angular elevation 90° corresponds to the zenith.

The calculations for a curve in Fig. 2 are the following. For each assumed value of D, find the auxiliary angle A from Equation 4, and then B from Equation 5. B is the angle at the center of the earth between orbit and station, measured along the meridian, and ϕ is the station latitude. Finally, from H and B find the angular elevation, h, by Equation 6, in which r is the radius of the earth, 3,963 miles.

Fig. 2 has been constructed for northern latitudes. The only changes needed for a diagram to be used in the Southern Hemisphere is to replace D by $180° - D$, and to interchange the labels "Northern Sky" and "Southern Sky."

CHARLES WHITNEY
Smithsonian Astrophysical Observatory

Two MOONWATCH Stations

Discomforts from summer's insects and winter's cold are minimized by indoor observing stations built by MOONWATCH teams in Milwaukee, Wisconsin, and Terre Haute, Indiana. Each building is designed so that satellites traveling in any direction, whether generally east-west or north-south, may be easily observed.

Milwaukee's MOONWATCH observatory is rotatable, on a circular track formed of 2-by-10-inch beams. Eight-inch steel truck casters revolve on an 8-foot radius about a 4-inch pipe, which serves as a turning center and hold-down. The plywood floor rests on 2-by-10-inch joists, and has an area of 8 by 20 feet. The walls are eight feet high, their interiors covered with tempered masonite.

A slot, 30 inches wide, may be opened to the sky across the roof and down two ends to table-top height. This allows observers with properly arranged telescopes to make sightings. The 14 MOONWATCH instruments, with mirrors, are mounted on opposite sides of the table, as seen in the photograph.

Terre Haute's building is much larger, with an area of 10 by 100 feet, lying in a true north-south direction. The roof, eight feet high, has 16 hinged metal doors, each in line with the mast (carrying a 20-foot crossbar) that projects through the center of the building. This arrangement provides for observing satellites crossing the sky east and west.

Objects moving in north-south orbits are observed through eight foot-square portholes on both the east and west walls. Under each of the 16 openings is a small table for a telescope.

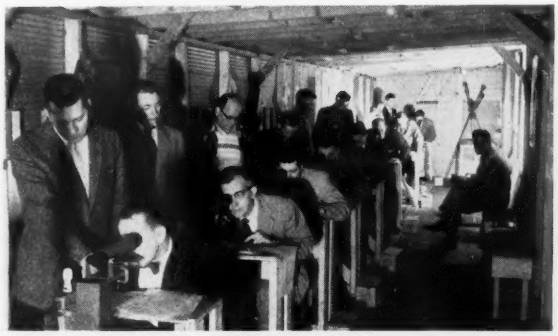
MOONWATCH Observations

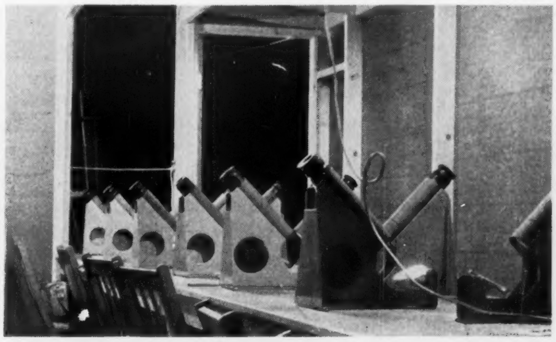
In recent months, the presence in the heavens of several artificial satellites has provided MOONWATCHERS in all parts of the world opportunity to gain observing experience akin to that of professionals. Since the observations of the first two Russian satellites reported in *Bulletin* No. 8, many teams have improved their observing skill and successfully picked up the three much fainter American satellites.

These MOONWATCH sightings, together with radio and radar observations, provided data from which the preliminary orbits were determined, and subsequently photographs of all three objects (1958α, β, and γ) were made at the Smithsonian precision camera-tracking stations. 1958δ was photographed within three days of its launching. In the past few days all 12 camera stations have gone into regular operation.

Scores of teams participated in the "death watch" of the second Russian satellite, $1957\beta1$, which fell near the northern coast of South America on April 13th. Sightings by teams in Millbrook, New York, New Haven, Connecticut, and Bryn Athyn, Pennsylvania, were followed within minutes by final observations from ships and islands in the Caribbean Sea.

The launching of the third Russian satellite (1958δ) on May 15, 1958, led to a generous batch of reports within the first few days. On the first few orbital passages, it became evident that Sputnik III was accompanied by at least three companions, for the Edinburg, Texas, team (066 026 098) reported sighting a train of four objects. These were apparently the rocket, the





Left: The Terre Haute station's observatory is oriented in a north-south direction, with individual observers viewing through metal hatches in the roof and portholes in the walls. The mast is to the extreme left of this scene. Right: Milwaukee's station uses a single table with telescopes on each side to view the sky through a 30-inch slot in the roof. The whole observatory is rotatable, so observations can be made of any part of the sky.

cone-shaped instrumented satellite, and two bodies of about 7th magnitude — probably the nose cone and one of the shields. Several teams observed both the rocket and the instrumented satellite on the first day.

Through May 20, 1958, 181 of the 232 teams in the United States and foreign countries reported 3,510 scientifically useful observations of all the artificial satellites, including 1958δ and its several components. This total was produced during 1,659 observing sessions.

Of the 128 teams in the United States, 109 produced 2,099 sightings during 937 observation sessions. The five stations in Australia held 59 sessions, amassing 206 observations; the four in the Union of South Africa, 144 sessions with 283 observations; and the 78 in Japan, 497 sessions with 886 sightings.

The following are American stations that reported observations, with the total number of productive observing sessions through May 20th.

Station	*Code Number*	*Sessions*
Sylacauga, Ala.	001 033 086	5
Phoenix, Ariz.	002 033 112	8
Tucson, Ariz.	003 032 111	28
Yuma, Ariz.	107 033 115	11
Altaville, Calif.	004 038 121	1
China Lake, Calif.	098 036 118	26
Los Altos, Calif.	005 037 122	9
Los Angeles, Calif.	100 034 118	9
Oakland, Calif.	006 038 122	11
Sacramento, Calif.	007 039 121	48
San Francisco, Calif.	008 038 122	4
San Jose, Calif.	134 037 122	1
Santa Barbara, Calif.	009 034 120	3
Santa Monica, Calif.	109 034 119	1
Stockton, Calif.	010 038 121	2
Sunnyvale, Calif.	078 037 122	1
Walnut Creek, Calif.	011 038 122	18
Whittier, Calif.	012 034 118	22
Denver, Colo.	013 040 105	19
New Haven, Conn.	087 041 072	13
Norwalk, Conn.	120 041 073	2
Washington, D. C.	014 039 077	14
Panama City, Fla.	091 030 086	1
St. Petersburg, Fla.	121 028 083	9
West Palm Beach, Fla.	016 027 080	20
Athens, Ga.	079 034 083	1
Decatur, Ga.	132 034 084	2
Hapeville, Ga.	017 034 084	2
Honolulu, Hawaii	114 021 158	2
Boise, Idaho	018 044 116	1
Idaho Falls, Idaho	019 043 112	8
Chicago, Ill.	020 042 088	2
Chicago, Ill.	085 042 088	4
Danville, Ill.	021 040 088	3
Lemont, Ill.	022 042 088	6
Peoria, Ill.	023 041 090	6
Rantoul, Ill.	092 040 088	3
Evansville, Ind.	094 038 088	3
Indianapolis, Ind.	024 040 086	1
Terre Haute, Ind.	025 039 087	10
Des Moines, Iowa	026 042 094	1
Manhattan, Kans.	027 039 096	19
Wichita, Kans.	028 038 097	14
Wilmore, Ky.	029 038 085	3
New Orleans, La.	030 030 090	11
New Orleans, La.	031 030 090	7
Baltimore, Md.	088 039 077	6
Silver Spring, Md.	032 039 077	5
Cambridge, Mass.	099 042 071	33
Detroit, Mich.	033 042 083	2
Lansing, Mich.	034 043 084	3
St. Paul-Minneapolis, Minn.	035 045 093	20
Biloxi, Miss.	090 030 089	9
Kansas City, Mo.	036 039 095	9
St. Louis, Mo.	080 039 090	7
Lincoln, Nebr.	038 041 097	5
Dover, N. J.	039 041 075	4
Paterson, N. J.	108 041 074	2
Red Bank, N. J.	040 040 074	5
Alamogordo, N. M.	102 033 106	19
Albuquerque, N. M.	041 035 107	26
Albuquerque, N. M.	103 035 106	15
Las Cruces, N. M.	042 032 107	10
Los Alamos, N. M.	043 036 106	18
Millbrook, N. Y.	045 042 074	7
New York, N. Y.	046 041 074	5
Schenectady, N. Y.	081 043 074	6
Cary, N. C.	112 036 079	2
Greensboro, N. C.	049 036 080	12
Cincinnati, Ohio	050 039 085	3
Cleveland, Ohio	052 042 082	5
Columbus, Ohio	051 040 083	3
Dayton, Ohio	082 040 084	14
North Canton, Ohio	053 041 081	11
Struthers, Ohio	075 041 081	1
Bartlesville, Okla.	126 037 096	3
Lawton, Okla.	110 035 098	16
Oklahoma City, Okla.	135 036 098	5
Tulsa, Okla.	054 036 096	10
Portland, Ore.	076 045 123	9
Bryn Athyn, Pa.	055 040 075	23
Chambersburg, Pa.	056 040 078	1
Harrisburg, Pa.	057 040 077	2
Philadelphia, Pa.	058 040 075	2
Pittsburgh, Pa.	059 040 080	3
State College, Pa.	060 041 078	6
Yankton, S. D.	061 043 097	8
Bristol, Tenn.	097 037 082	8
Chattanooga, Tenn.	062 035 085	5
Memphis, Tenn.	123 035 090	2
Amarillo, Tex.	064 035 102	16
Big Spring, Tex.	083 032 101	3
Bryan, Tex.	065 031 096	7
Dallas, Tex.	129 033 097	1
Edinburg, Tex.	066 026 098	20
El Paso, Tex.	104 032 106	4
Ft. Worth, Tex.	068 033 097	7
Ft. Worth, Tex.	069 033 097	13
San Angelo, Tex.	105 031 100	5
San Antonio, Tex.	089 029 098	13
San Antonio, Tex.	096 030 098	8
Waco, Tex.	070 032 097	2
Waco, Tex.	093 032 097	2
Wichita Falls, Tex.	136 034 099	1
Arlington, Va.	071 039 077	9
Ft. Belvoir, Va.	077 039 077	12
Harrisonburg, Va.	072 038 079	6
Roanoke, Va.	073 037 080	6
Spokane, Wash.	086 048 118	9
Milwaukee, Wisc.	074 043 088	27

LEON CAMPBELL, JR.

MOONWATCH TEAM REGISTRATIONS SINCE BULLETIN NO. 8

IN THE UNITED STATES:

Location	*Code Number*	*Leader*
Tempe, Ariz.	130 033 112	Dr. F. G. Yale
San Diego, Calif.	133 033 117	Dr. A. Morris
San Jose, Calif.	134 037 122	S. W. Bieda, Jr.
New London, Conn.	138 042 072	E. P. Oths
Decatur, Ga.	132 034 084	W. H. Close
Hapeville, Ga.	131 034 084	R. H. Grantham
Salem, Ill.	128 039 089	H. E. Mueller
Reno, Nev.	127 040 120	Lt. W. B. Crow
Albuquerque, N. M.	103 035 106	Capt. K. W. Shaw
Bartlesville, Okla.	126 037 096	Dr. N. G. Foster
Oklahoma City, Okla.	135 036 098	W. B. Robinson
Dallas, Tex.	129 033 097	Dr. J. B. Allen
Wichita Falls, Tex.	136 034 099	CWO K. B. Schooley

IN OTHER COUNTRIES:

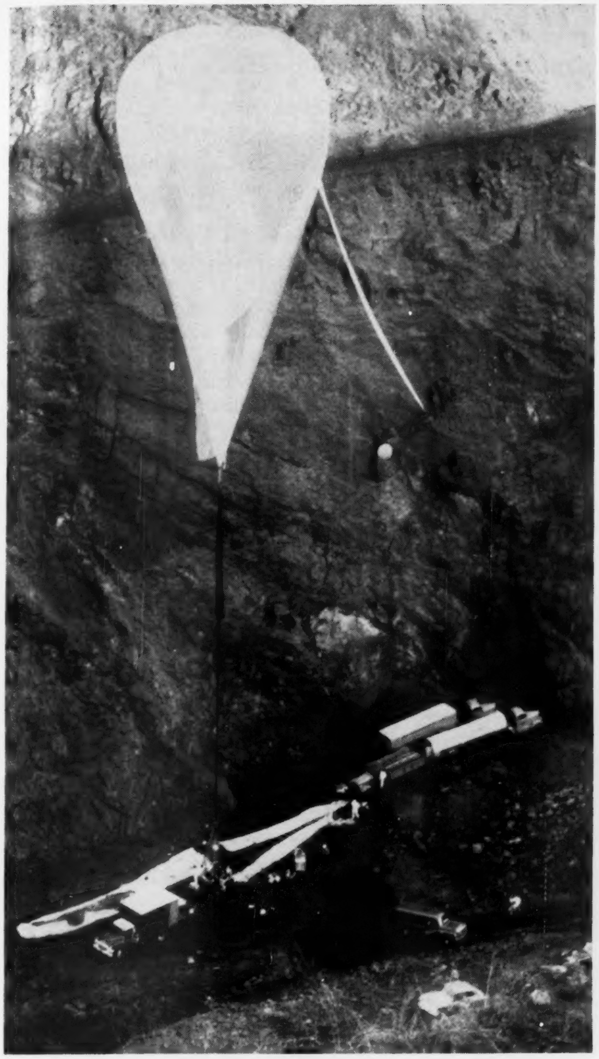
Location	*Code Number*	*Leader*
Agana, Guam	137 014 325	G. M. Perdew
Melbourne, Australia	604 128 325	W. G. H. Tregear
Montreal, Canada	450 046 074	C. M. Good
Quito, Ecuador	809 090 078	Col. B. Zurita
Guatemala City, Guat.	902 015 091	J. Vassaux
Shiraz, Iran	503 030 233	E. Lerch
Pasay City, Philippines	501 015 301	H. Arber
Taipei, Taiwan	502 025 301	C. H. Tsai

IN GERMANY:

Location	*Code Number*	*Leader*
Berlin	700 052 193	J. Herrmann
Bochum	701 052 187	H. Kaminski
Hannover	702 052 190	Prof. R. Hase
Munich	703 048 191	H. Oberndorfer
Recklinghausen	704 052 187	V. Dahlkamp
Ulm/Donau	705 048 190	Dr. Durst
Weissenau	706 048 190	Prof. J. Bartels

IN JAPAN:

Location	*Code Number*	*Leader*
Katsuura	276 034 316	
Kurashiki	275 035 314	
Kyoto University	279 035 316	
Shirahama A	277 035 319	
Shirahama B	278 035 319	
Tsukiyi	274 036 320	



Cables hold the straining plastic balloon in place just before launching from an open-pit iron mine, while crews ready the two balloonists for the flight.

Commander Ross, left, and Astronomer Mikesell check their equipment after their overnight ascent through the tropopause into the quiet thin air of the stratosphere.

THE STARS DO NOT TWINKLE AT 40,000 FEET

Two space explorers, a seasoned balloonist and the first astronomer to observe the heavens from the stratosphere, said on Wednesday, May 7th, that the stars do not twinkle when observed from 40,000 feet.

Navy Commander Malcolm D. Ross and Naval Observatory astronomer Alfred H. Mikesell smiled through beard stubble as they reported the success of their experimental balloon flight.

The balloon came down in a clover field near Dubuque, Iowa, at 8:26 a.m., May 7th. The flight to 40,000 feet in an open fiberglass basket began nearly 12 hours earlier, at 8:50 p.m., from Crosby, Minnesota.

Happiness showed through the fatigue on their faces as Ross and Mikesell talked to newsmen. Mikesell, 44, an astronomer whose specialty is studying the scintillation of stars, said the view was the best he ever had.

While Ross is an experienced aeronaut, he was impressed by the way Mikesell had described the moon, planets, and stars from their 2½-by-4-foot platform in the sky. "It was just wonderful listening to him," the Navy officer said.

The ascent provided the first flight test of techniques to be used some day in recording men's physical reactions in an orbiting satellite. Heartbeats, respiration, and other physical data were recorded by radio and transmitted 1,300 miles by telephone to a Navy medical research laboratory near Washington.

The only defect thus far reported in the experiment was that a pressure-breathing arrangement designed as a safety factor might be a hazard instead.

Captain Norman L. Barr, a medical officer at the Naval laboratory, said one of the men had had a decrease in the rate of electrical conduction from the top to the bottom of his heart.

This apparently happened, Captain Barr said, about the time that an automatic device cut in at 37,000 feet to increase pressure inside the men's oxygen masks. He said the device would have to be re-evaluated if it was found that the pressure breathing had caused the heart condition.

The flight was a project of the Office of Naval Research. General Mills built and launched the balloon and gondola under a contract with the Navy.

The landing near Dubuque did not damage the delicate equipment aboard the balloon. Ross maneuvered the big bag away from river bluffs and came down about a mile from the Mississippi River.

Mr. Mikesell chose a quartz-mirrored Questar telescope for the trip aloft because of its compactness, lightness, versatility, and ability to furnish good definition at high powers.

The De Luxe Questar, $995. With quartz mirror, $1,100. Extended payments if desired. Literature on request.

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OBSERVER'S PAGE

Universal time is used unless otherwise noted.

Observing the Moon — Posidonius

Situated on the northwestern border of Mare Serenitatis, this magnificent walled plain is one of the most imposing formations on the entire surface of the moon. It is shown here as seen in an inverting telescope, with south at the top and west at the left. Although Posidonius is actually circular, it appears somewhat foreshortened because of our oblique viewing angle.

The interior of Posidonius contains a great amount of detail which will repay careful study. Near the center is the conspicuous crater Posidonius A, six miles across, and just west of this is a semicircle of low hills that are probably remnants of an ancient crater. Julius Schmidt has reported that on one occasion Posidonius A appeared as only an indistinct bright spot, whereas Posidonius B (lower left in picture) was seen as a definite crater, half-filled with shadow.

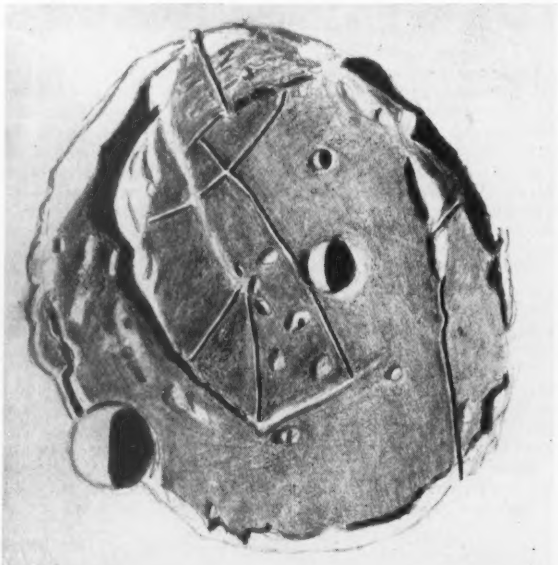
Of special interest is the series of ridges and clefts more or less concentric with the outer walls of Posidonius. These ridges have often been described by selenographers as the fragments of an inner ring, but if that were the case, how could these ridges have clefts as continuations? Perhaps the clefts predate the ridges and were the natural result of cooling and subsidence in the once-molten interior. Through these giant cracks in the crust later volcanic activity may have exuded material to form the ridges.

The cleft system itself merits a great deal of attention. Both the long central cleft and the one extending northward from the ridge near the east wall are comparatively conspicuous objects; they should not be too difficult to observe with apertures as small as four inches. The other clefts shown are much more difficult, normally requiring larger telescopes and critical conditions of seeing and illumination.

The history of the long central cleft is noteworthy. On the maps of Wilkins and Goodacre it is incorrectly drawn as intersecting the central crater, while the charts of Schmidt and Neison correctly represent it as passing to the west. Elger's original chart does not show it at all. The short cleft extending to the small craterlet on the south wall is not on any of the maps mentioned.

ALIKA K. HERRING
3273 Liberty Blvd.
South Gate, Calif.

The lunar walled plain Posidonius. For his drawing Alika K. Herring used a 12½-inch reflector with a 228x eyepiece, on September 13, 1957, at 9:05 UT. It was then late lunar afternoon in the neighborhood of Posidonius, the sun being only seven degrees high. Nevertheless, the shadows cast by the ramparts were short, proving them to be low. South is at the top.



AURORA ON MAY 13-14

Two Pennsylvania amateurs saw an auroral display during the night of May 13-14. Walter A. Feibelman, at Pittsburgh, first observed faint rays in the north at 11 p.m., then a low arc that lasted about half an hour. He photographed the arcs and rays, and observed a faint glow as late as 3:30 in the morning. At the same time David R. Kaiser, at Eightyfour, who had arisen to make his nightly auroral check, saw a slightly pulsating drapery, its altitude being 25 degrees.

GRAZING LUNAR ECLIPSE

The lunar eclipse of May 3rd was observed by four of us from the John Muir high school in Pasadena: Stanley Ulfeldt, John Beebee, James Hauxhurst, and myself. We took the photographs on page 444 from the Mojave Desert, at a place north of Palmdale, California.

A 6-inch f/8 Newtonian reflector was

used with a 1¼-inch Erfle eyepiece. The lens of a Contaflex camera was set at infinity, and the eyepiece was used to focus a ⅜-inch image of the moon on the camera ground glass. The Perutz Perpanic 17 film (ASA speed rating 40) was developed in Clayton P20 for 12 minutes, and the prints were dodged to secure good rendition of details.

GREGORY SMITH
4055 Alta Vista Dr.
Pasadena 3, Calif.

SUNSPOT NUMBERS

The following American sunspot numbers for April were derived by Dr. Sarah J. Hill of Whitin Observatory, Wellesley College, from AAVSO observations.

April 1, 261; **2**, 271; **3**, 227; **4**, 281; **5**, 276; **6**, 235; **7**, 201; **8**, 206; **9**, 176; **10**, 174; **11**, 154; **12**, 105; **13**, 117; **14**, 92; **15**, 119; **16**, 111; **17**, 145; **18**, 157; **19**, 159; **20**, 161; **21**, 176; **22**, 175; **23**, 179; **24**, 164; **25**, 144; **26**, 173; **27**, 155; **28**, 187; **29**, 188; **30**, 223. Mean for April, 179.7.

Below are observed mean relative sunspot numbers from Zurich Observatory and its stations in Locarno and Arosa.

May 1, 250; **2**, 246; **3**, 269; **4**, 268; **5**, 267; **6**, 223; **7**, 198; **8**, 177; **9**, 150; **10**, 181; **11**, 166; **12**, 160; **13**, 114; **14**, 103; **15**, 106; **16**, 110; **17**, 116; **18**, 123; **19**, 140; **20**, 132; **21**, 162; **22**, 165; **23**, 171; **24**, 204; **25**, 192; **26**, 170; **27**, 157; **28**, 160; **29**, 192; **30**, 178; **31**, 181. Mean for May, 175.2.

DEEP-SKY WONDERS

Beginners who wish to explore the glittering splendor of star clusters can start with a good pair of opera glasses or higher-power field glasses. Indeed, for a half century many American amateurs have gained their start in astronomy from Garrett P. Serviss' book, *Astronomy with an Opera-Glass,* which can be found in many libraries today.

The large field of view of prism binoculars makes them more suitable than Galilean-type glasses. Yet, as a schoolboy I had a lot of fun with a homemade opera glass having a 3-inch objective and a simple concave-lens eyepiece, mounted with paste in a tube of rolled newspaper. Binoculars (or monoculars) with 50-millimeter objectives and magnifying seven times are very satisfactory, having a large field of view. Inexpensive war-surplus M-17 elbow telescopes are also good low-power wide-field instruments.

An observer of clusters and nebulae needs a dark, transparent night, one without moonlight or high cirrus cloud. All seven stars of the Little Dipper should be easily visible, the faintest, Eta (η) Ursae Minoris, being magnitude 5.0. Next to Zeta (ζ), where the handle joins the Little Dipper bowl, is a better test, Theta (θ) Ursae Minoris, of magnitude 5.3. Another test star is R Coronae Borealis, 6th magnitude, near the center of the Northern Crown, but at rare intervals

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(3) EYEPIECE MOUNT — Standard 1¼ inch with exclusive double-draw and rack-and-pinion focusing. Adjustable for three inches of travel to accommodate any eyepiece, positive or negative. Built-in diagonal mirror has a surface finished to ⅛ wave.

(4) THREE EYEPIECES — 18-mm. Huygens, 9-mm. achromatic Ramsden, 6-mm. Orthoscopic, giving powers of 65x, 130x, and 195x.

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The DeLuxe Dynascope comes to you complete with every part and feature exactly as described and illustrated here. Each instrument is carefully triple-tested before shipment and is accompanied by the inspector's performance report. Specially packed, it is ready to be set up for observing a few minutes after unpacking. Shipment is f.o.b. Hartford, Conn., express charges collect (weight 21 pounds). There is nothing else to buy, no added costs, no extras of any kind needed.

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this normally naked-eye star becomes very much fainter.

As the star chart on page 485 shows, at this time of year the constellation of Scorpius is well placed in the southern sky. Look with binoculars just west of Antares for a faint, hazy patch of light, easily seen on a clear night. If you do not find it at first, let your eye rove around the field until the object appears "in the corner of your eye." This observing technique, known as averted vision, shows objects about a magnitude too faint to be visible by direct gazing.

This hazy patch is M4, a globular cluster consisting of thousands of closely grouped stars. If it were located away from the luminous background of the Milky Way, it would be an unmistakable naked-eye object. Through a 3- to 6-inch telescope you can see individual stars on the edges of the cluster, but even very large instruments cannot resolve its star-packed center. The name M4 means that this is the fourth object in the catalogue of Charles Messier, the famous 18th-century comet hunter. It is also known as NGC 6121, its number in the *New General Catalogue of Nebulae and Clusters.*

M5, though a little harder to find than M4, is another interesting globular. Look high up the sky above Antares for the stars Alpha (α) and Epsilon (ϵ) Serpentis, of the 2nd and 3rd magnitudes, respectively. This pair is just under the X-shaped head of Serpens, and should not be confused with Delta (δ) and Epsilon Ophiuchi, some 12° below.

Starting at Alpha Serpentis, move your binoculars about 8° southwest, at right angles to the line joining Alpha and Epsilon. You will come to a loose line of four faint stars running east to west. In order, these are 10 Serpentis, 5 Serpentis, 110 Virginis, and 109 Virginis. The right-angled line will go through 5 Serpentis, and the hazy patch almost in contact with this star is M5. In a good telescope this cluster is a splendid sight.

If the night is really clear, the Milky Way will be conspicuous across the eastern sky. Look for 1st-magnitude Altair, halfway up the sky and a little south of east. Like Antares, it is flanked by two guard stars. Follow the Milky Way south and west for about 22° until you come to a brighter patch, shaped something like a shield and about 4° in diameter. A curved line of faint stars stretches across the top of the shield, and just below the western end of this line binoculars will show another fine cluster.

This time you have found M11, one of the great sights of summer skies. It is a galactic cluster, having hundreds of stars instead of the thousands of a globular. Here the center is not a blurred glow as in M5, but you can see individual stars. In a 6-inch telescope, M5 is studded with dancing specks of light.

WALTER SCOTT HOUSTON
Rte. 3, Manhattan, Kans.

BOOKS AND THE SKY

THE DAWN OF LIFE

J. H. Rush. Hanover House, Garden City, N. Y., 1957. 262 pages. $4.50.

"THIS BOOK is not intended to give an answer to the riddle of life's origin, but to point a direction. . . . That direction is expressed in the conviction that life is a natural phenomenon in the same sense that the phenomena of inanimate matter are natural, and that life will develop out of nonliving material wherever suitable conditions prevail for a sufficient time."

In attempting to outline the present state of research and thinking on this fascinating subject, Dr. Rush has very ably covered a tremendous field of knowledge from astronomy and physics to geology, paleontology, biology, and chemistry. He remarks, "Hardly an area of science fails to throw some light on the question of life and its origin." The author has an easy, informal style that leads the reader gently through the technicalities of each particular field without getting lost in them. He has brilliantly succeeded in piecing together the various lines of evidence in such a way that details do not obscure their significance.

The first three of the book's 12 chapters deal with some fundamental principles of physics, especially of thermodynamics and kinetic theory, insofar as they illuminate the unique properties of life; with theories, old and new, of the origin of the solar system and the cosmic time-scale; with the formation of the earth and the composition of its surface and atmosphere before the appearance of life.

The next four chapters discuss the central problem: the chemistry of hydrocarbons and the basic structures of living things, theories of life formation in the primeval waters loaded with organic compounds ("the soup that ate itself up"), and the subsequent accelerated chemical and biological evolution marked by the great breakthrough of photosynthesis. This section should prove the most interesting to astronomers, who often are not nearly as familiar with recent developments in the biology, biochemistry, and biophysics of complex organic compounds as they are with the physics and chemistry of the much simpler inorganic molecules. For all its puzzling aspects, the problem of stellar evolution seems like child's play compared with the complexity of organic evolution! For the author to have maintained a sense of continuity throughout this section of the story is no minor feat.

A chapter on life in the universe brings us to more familiar ground. It deals with the conventional data on the planets and comes to the usual negative conclusion for all but Mars, where some doubt remains. It is in this and in some of the first chapters that the astronomer can test the adequacy and reliability of Dr. Rush's documentation; the result of the test is most encouraging. His discussion of the possibility of life without carbon chemistry is more complete than usual, but the conclusion is still negative.

The final chapter discusses briefly the emergence of mind and the mystery of relations between brain and mind. Here, however, it comes rather as a surprise that Dr. Rush seems to consider seriously such psychic "phenomena" as extrasensory perception, psychokinesis, and clairvoyance. He says, "No one can properly appreciate the force of the evidence for these effects unless he studies the detailed reports in the field and tries some experiments." This reviewer would like to refer interested readers to the recent debate on this subject in *Science, 122,* 359-367, 1955, and *123,* 7-19, 1956.

This excellent digest of a difficult subject is a welcome addition to serious popular literature and should be valuable to the teaching profession. There is a well-selected bibliography of two dozen books.

G. DE VAUCOULEURS
Lowell Observatory

THE TELESCOPE

Harry Edward Neal. Julian Messner, Inc., New York, 1958. 192 pages. $3.50.

INTENDED for young people with little previous knowledge of astronomy or telescopes, this book is, as the author says, far from a complete history of astronomical instruments. However, it recounts the main advances in telescope making, and should be enjoyable reading even for the more serious amateur.

Mr. Neal describes vividly the dedication of many men to the difficult art of building telescopes. We read of William Herschel polishing mirrors for 16 hours at a stretch, his only food being what his sister Caroline put in his mouth. While he was a professional musician, Herschel would often dash home during intermissions of concerts he was conducting to take a quick look at the stars!

Most of us are familiar with the difficulties encountered by the Corning Glass Works in making the glass disk for the 200-inch mirror. Mr. Neal tells about the similar troubles experienced a hundred years earlier by the Earl of Rosse, who made a reflector with a four-ton metal mirror, six feet in diameter. The disk was poured in much the same way as the 200-inch glass, then cooled for four months, only to crack at the onset of grinding. Three more imperfect disks were cast, but finally a good one. Two years were required for constructing the mounting, and three for grinding and figuring the mirror, before the telescope was completed in 1845. It was with this instru-

ment that spiral nebulae were first recognized as such.

One overly enthusiastic telescope lover was the first director of Allegheny Observatory, Prof. Philotus Dean, who decided that its new 13-inch refractor should not be *used* but *preserved!* Preserve it he did, very effectively with the aid of a shotgun, until the members of the Allegheny Telescope Association, who had financed the venture, lost interest in astronomy and presented the instrument to the University of Pittsburgh. The author does not tell how the professor was finally "retired," but the second director, S. P. Langley, was destined to become famous by using rather than preserving the equipment.

Besides its sampling of telescope history, the book provides information on the Astronomical League, observing societies, astronomical books and magazines, and suppliers of equipment.

It is difficult to tell the story of telescopes without bringing in some of the major astronomical discoveries made with them. But in a book this brief the author might well have omitted some minor astronomical events and supplied more details on some major ones. Adding a few astronomical photographs to the pictures of famous astronomers and telescopes would have helped.

The diagrams are often confusing and misleading. In those illustrating the principles of telescopes, the light rays are incorrectly drawn in most cases.

KENNETH M. YOSS
Louisiana State University

TEACHING SCIENCE TO THE ORDINARY PUPIL

K. Laybourn and **C. H. Bailey**. Philosophical Library, New York, 1957. 415 pages. $10.00.

AFTER many months of public din about the gifted child and his alleged lack of educational challenge, it is refreshing to pick up a book designed to improve the education of the ordinary student. The authors point out, with considerable truth, that the gifted and the retarded draw and receive attention in the classroom while other children — the majority of the group — often receive less than their share.

This book was written to assist teachers in making science more meaningful through practical demonstrations and experiments. It is not concerned with abstract facts and generalizations. The authors sought to present the full range of general-science subject matter, and to suggest student activities that would foster familiarity with the scientific method of gaining knowledge.

As a source book for teachers, it serves its purpose admirably. The 25 chapters deal with most of the areas needed for a general-science foundation: two concern air phenomena, eight living things, two

water, three heat and electricity, three sound and sight phenomena, one stars and space, four forces and machines, one soil, and one how life is handed on.

Each chapter begins with an introduction for the teacher, followed by suggestions for first-hand experiences, demonstrations, models, and experiments, fully illustrated with clear line drawings. Altogether there are 536 items explained and depicted — a tremendous amount of valuable information for any instructor desirous of making science interesting and understandable to his pupils. Of these items 25 deal with stars and space. The authors built and tested every piece of equipment suggested; virtually all can be made from easy-to-procure materials.

This book is the result of a full-scale study of a suitable science curriculum for ordinary children in British secondary schools by a committee of 14 headmasters and science specialists. In this reviewer's judgment it is appropriate for most American junior high schools and many upper elementary grades.

It can be recommended without reservation, beyond a regret that a few British terms and names are unfamiliar — for example, petrol, perspex, and sellotape. Basically, the book is valuable to teachers everywhere and will be welcomed by those responsible for the improvement of general-science education.

JOHN STERNIG
Ass't. Superintendent of Schools
Glencoe, Ill.

NEW BOOKS RECEIVED

The Astronomer's Universe, *Bart J. Bok*, 1958, *Melbourne University Press*, Carlton, N. 3, Victoria, Australia. 107 pages. 21s.

Four public lectures, given in Australia by the director of Mount Stromlo Observatory, have been expanded by him, giving laymen an informed view of recent progress in stellar astronomy.

Introduction to the Moon, *Dinsmore Alter*, 1958, *Griffith Observatory*, P. O. Box 27787, Los Angeles 27, Calif. 108 pages. $1.65, paper bound.

The former director of Griffith Observatory has written this nontechnical summary of current knowledge about our moon, illustrating it generously with lunar photographs, mostly taken with the Lick 36-inch refractor and the Mount Wilson 60-inch reflector.

Light: Visible and Invisible, *Eduard Ruechardt*, 1958, *University of Michigan Press*. 201 pages. $4.50.

Light and its properties are explained for the general reader by a professor at the University of Munich. The translation is the fourth in the "Ann Arbor Science Library" series.

Le Volcanisme Lunaire et Terrestre, *Alexandre Dauvillier*, 1958, *Editions Albin Michel*, 22 Rue Huyghens, Paris, France. 300 pages. 1,200 fr, paper bound.

The part played by volcanism in shaping the surface features of the earth and moon is discussed in this semipopular account, written in French by a professor at the College de France. The volume is one of the "Sciences d'Aujourd'hui" series.

GLEANINGS FOR ATM's

CONDUCTED BY ROBERT E. COX

Using Spherometers in Maksutov Radius Testing

RADIUS CONTROL of the surfaces of Maksutov lens elements presents a serious problem to amateurs making such optical parts. In April we described an optical tester that could be used during advanced-fine-grinding and polishing stages. For radius control during grinding and smoothing with carborundum, a spherometer or comparator is essential.

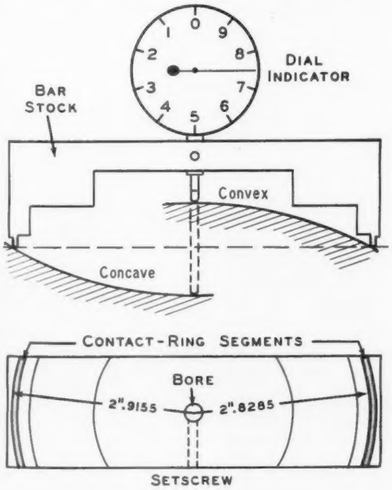
Spherometers. Perhaps most widely known in this country is the ball type of spherometer, consisting of a metal plate with three upright posts 120° apart and at a prescribed distance from a centered indicating device. At the foot of each post is an accurately made ball bearing. For real precision, each leg should be located with dividing-head accuracy, a job for a master mechanic.

Ball spherometers have the disadvantage that the readings must be corrected by the radius of the balls. P. M. Casady gave formulae for this correction in *Sky and Telescope* for August, 1949, where he describes a ball spherometer without legs. But a modification of his design would be necessary to accommodate the steep surfaces of Maksutov lenses.

The ring-type spherometer, generally used in European optical shops, requires no correction. It is made from a thick-walled metal cylinder machined and ground to very sharp edges, the inside and outside diameters being measured to the highest possible accuracy. When not in use, the device is set on a felt pad to protect the delicate edges from damage.

A simplified ring spherometer has been designed by John Gregory, Springdale, Connecticut; it is shown in the diagram. He writes:

"Hold a bar of cold-rolled or stainless



With an extension on the plunger, the Gregory spherometer can be used for concave as well as convex surfaces.

steel in a four-jaw chuck, turning it so there are two circular sharp edges and a concentric bore which will accommodate a dial indicator or a micrometer spindle shaft. The latter should have a cap with a rounded head, but it is possible to measure the shaft diameter of a flat-ended spindle and to make allowances when testing a concave surface.

"In use, first adjust the micrometer to zero on a flat comparison plate, or read the setting and allow for it when measuring the lens. If extra stock has been left in the measuring ring, nicked or beveled edges can be ground down on a flat plate."

Because the depth on the surfaces of a 6-inch Maksutov corrector is close to 0.75", be sure to allow enough clearance on the under side of the spherometer for the convex surface (partially shown in position in the diagram). Yet there must be sufficient stock in the bar to prevent warping during measurement. As for the concave surface, to measure this with the same spherometer will require adding an extension of 1.0000", as shown by the dashed lines. If a Brown and Sharpe 1" micrometer spindle (costing about $11) reading to 0.0001" is used, the shank length and spindle extension are great enough so that only a small cap need be added to permit readings on both surfaces of a 6-inch Maksutov corrector.

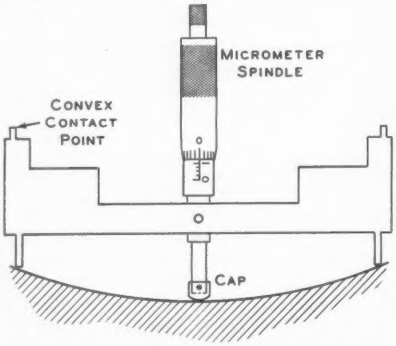
Note that for the convex surface the dial-indicator or micrometer-spindle reading gives a positive indication of sagitta, whereas for the concave surface this is negative. In the first case, the indicating plunger is raised high above the plane of the contact ring segments, at which it would read zero. To make a concave-surface reading, however, it is necessary to insert the extension and zero the spherometer on the flat so the dial reads at the top limit of its travel. When it is placed on the concave surface the plunger will drop down to contact the curve, giving a lower reading. The sagitta is then 1.0000" minus the reading of the dial or micrometer.

For highest accuracy, the contact-ring diameter should be as great as possible, yet slightly smaller than the diameter of the largest surface to be fitted. For thickness between the two edges, 0.05" should be satisfactory, providing good support and protection from handling. The outside ring could be turned to 5.90", the inside one to 5.8". More convenient diameters for using the formula* might be 5.831" and 5.657", for which the

*The exact formula, $S = R - (R^2 - r^2)^{\frac{1}{2}}$ must be used for such a steep curve. R is the radius of the lens surface and r is the radius of the spherometer contact ring.

squares of the radii come out an even 8.500 and 8.000, respectively. The wall thickness would be 0.087″.

Another way to provide for both concave and convex surfaces with the Gregory-type spherometer is to build two of them. If the ring diameters are equal, the same r^2 can be used in all calculations. Another solution is to make a double-sided bar, one for convex and one for concave surfaces, as shown in the diagram. This requires accurate tooling, since the bar must be removed from the headstock of the lathe and reversed to make the second ring cut.



This spherometer tests convex surfaces on one side, concave on the other.

Accuracy. Burt Norman, Franklin Centre, Quebec, has sent this department a simplified version of the formula given in the February, 1957, issue, for obtaining the radius from a sagitta reading, S. It is

$$R = r^2/2S + S/2,$$

and avoids the necessity of squaring S.

To how many decimal places should we make our sagitta readings? Let us use figures that have been given for the $\mathbf{R}_1$ surface of the 6-inch Gregory-Maksutov, radius of curvature 6.583″, diameter 6″. Assuming that the measuring radius is exactly 3″, the sagitta is 0.7233″. For a spherometer reading only to 0.001″, we would calculate the radius of curvature using 0.723″, and the answer would turn out 0.003″ too large. However, if the sagitta is read to 0.0001″ as 0.7233″, the computation of the radius would be exactly right. It is evident that for finding the radius to the nearest thousandth, on a 6″ surface, the indicator should read to a 10-thousandth.

Care must be taken in using dial indicators for this work. For the large travel necessary in checking steep curves, requiring many spins of the indicator, inconsistent scale readings may be obtained if the internal gearing mechanism has become worn. It is not uncommon, after a dial indicator has been in use for some time, to have an error of one or two divisions over half its complete travel. Although considerably less expensive than dial indicators, micrometers suffer less wear, but adjusting them takes patience.

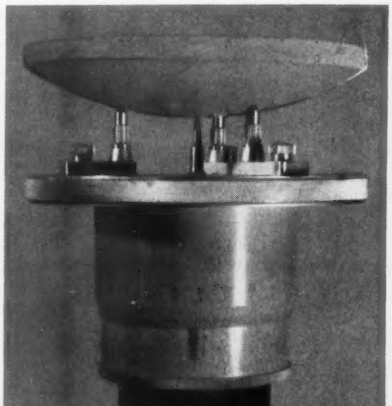
Comparators. The necessity to make absolute readings with a spherometer can be avoided if a spherometer-type instrument is used to compare a known surface with the one being tested. Many less expensive comparators will suffice and even the dial indicator or micrometer spindle can be dispensed with, as we shall see later.

If several lenses of the same design are intended, a master surface of the desired radius can be made and a spherometer of any type used as a comparator. The surface is worked until its sagitta reading matches that of the master. With six f/15 and five f/23 Gregory-Maksutov instruments under construction, the Amateur Telescope Makers of Boston are employing this method.

The master plates were made by Paul Valleli, using the precision spherometer pictured below. Their surfaces were ground, but not polished, and the sagitta of each master controlled within 0.00001″. The amateurs use a dial indicator reading to 0.0001″; with care readings within about five wave lengths of light can be obtained.

Professional optical workers polish and figure master surfaces of the desired radius, testing by interference fringes. For amateurs, however, this method is unattractive, since placing two surfaces in contact may produce scratches.

Sagitta-height standards. For comparator work, a master surface need not be



A $700 precision spherometer that has sapphire contact points. The graduated drum is used to set the desired sagitta within 0.0001″. The dial indicator shows that the Maksutov lens surface under test is flat by that amount.

Illustrated above is the 6" De Luxe Dynascope.

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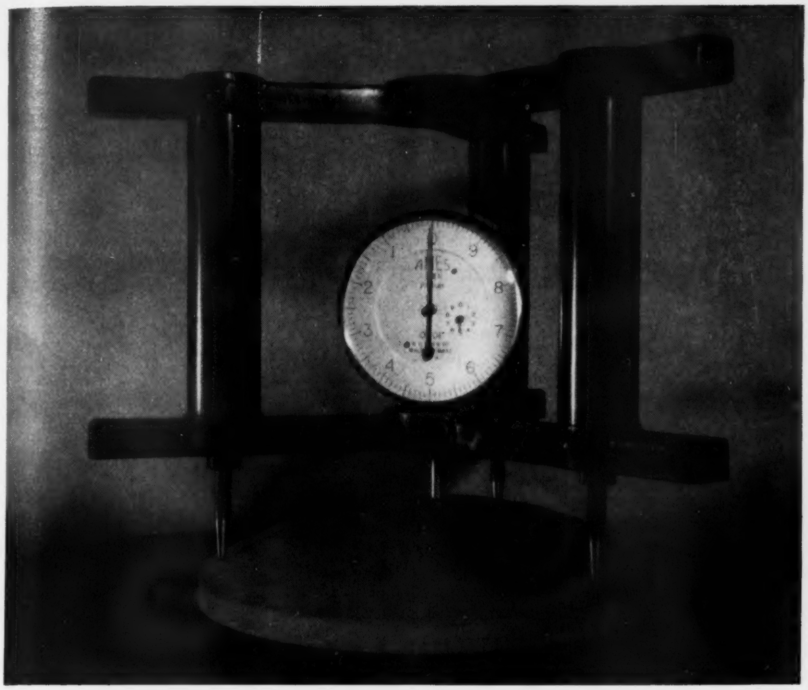


This mechanical comparator, designed by A. D. Jones, is the prototype of the one built by the Amateur Telescope Makers of Boston. Here it is being zeroed on an accurate standard Maksutov surface; when placed on another lens, the dial will show directly the difference in sagittae to 0.0001″.

used if, instead, carefully made blocks of the exact sagitta height are available. Such height standards also serve to limit the travel of the dial indicator or micrometer spindle, so these latter devices may be less expensive and the inaccuracies of long dial travel avoided.

First, compute the sagittae of the surfaces to be tested, using the radii of the spherometer contact ring or points as the values of *r*. If a Gregory-type spherometer has been constructed, with contact-ring diameters of 5.831″ and 5.657″, as suggested above, r^2 is 8.500 for the outside edge and 8.000 for the inside one. The sagitta for the $\mathbf{R}_1$ (6.583″) surface of the f/15 correcting lens becomes 0.6080″, and for the $\mathbf{R}_2$ (6.888″) surface it is 0.6075″.

Three precision blocks are made, with micrometer accuracy to 0.0001″, two with heights of 0.6080″ and one of 0.6075″. Their top and bottom surfaces must be as nearly parallel as possible. It is also important to have a good flat surface, of polished metal, plate glass, or other material that tests flat with a precision straightedge.

To read the concave lens, place the comparator on the flat surface with one of the 0.6080″ blocks under each ring segment. The dial indicator reading is recorded, and the comparator is placed on the lens, where any difference between the readings is the error in its sagitta. For a convex surface, the comparator is placed on the flat and a reading taken with the single 0.6075″ height standard placed under the indicator pin. Again, on the lens any difference is the error.

If the difference in sagitta is 0.010″ or less, then a very simple formula indicates the error in the radius of curvature:

$$\Delta R = \Delta S \times 2R^2/r^2,$$

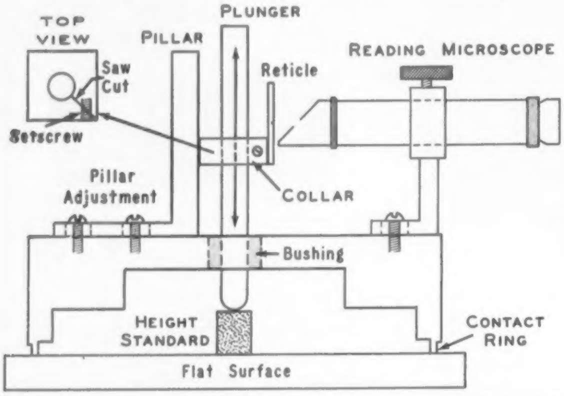
where ΔR and ΔS are the respective sagitta and radius-of-curvature differences. As an example, using a comparator in which r^2 is 8.500″ to test a concave surface for which *R* should be 6.583″, suppose the test reading is larger by 0.004″ than the reading on the height-standard blocks. The radius is too long by 0.004 × 10.192, or 0.0408″, and the actual value at the time of measurement is 6.6238″ instead of the required 6.583″.

A simplified comparator. Micrometer spindles and dial indicators are subject to

damage if handled improperly. A common accident is jamming of the central shaft against a lens surface for which the sagitta has been badly underestimated. The instrument pictured here uses a machined bar, but a smoothly operating central plunger does away with the possibility of accidental damage. Readings can be made to 0.0005", but height-standard blocks are needed unless a test surface is available.

Stainless steel is the best plunger material. It is advisable to make the central bore large enough to take a press-fitted bronze oilless bushing for the plunger to slide upon. A square collar is placed on the shaft, held in position by a setscrew, and carrying a reticle with a fine vertical scale, the engraved side away from the collar and plunger shaft. The surface of the pillar column should make a firm sliding contact with the other side of the square collar. To assure this and eliminate play in the plunger, touch up the adjoining pillar and collar surfaces with fine emeries; also provide an adjusting slot in the pillar support on the base of the instrument.

A magnifying device is necessary to read the difference between the plunger's contact position on a height standard and on the lens surface. Low-power microscopes with built-in reticles are commercially available, such as Edmund Scientific's 50-power pocket microscope. This item has a reticle measuring 0.1" in steps of 0.001", and readings can be estimated to 0.0005". Its 45-degree chrome-coated tip illuminates the field of view when turned to bright light. As the focus is fixed, the microscope is tilted back and forth with the tip in contact with the subject under observation. For use on the comparator the end must be cut off about 1/16" to provide clearance for movement of the plunger reticle. Set the microscope so its fixed reticle is at right angles to the movable one and focus carefully on the latter.



In the spherometers for which diagrams are shown on pages 473 and 474, the dial indicators and micrometer spindles may be interchanged. But if such devices are not available, a reading microscope can be used with this plunger-type comparator.

To avoid parallax effects, work from the middle of the microscope's reticle range, the 0.050" inch line. The range on either side of this should be sufficient for all sagitta differences after the surface has been brought as close as possible to proper radius of curvature — using even a simple cardboard template.

To make a setting, loosen the set screw on the collar and bring the movable reticle line into view in the microscope, moving it until one edge of this line just touches either the top or bottom of the 0.050" microscope line. Do not try to overlap or split the line images, as the method above of setting is easier and more accurate. Use this same procedure for both the readings on a height standard and the surface under test.

The inverted field of a pocket microscope can cause confusion in interpreting the readings. On a concave surface, if the reticle rises above the 0.050" microscope line, then the radius of curvature is shorter than it should be.

R. E. C.

CELESTIAL CALENDAR

Universal time is used unless otherwise noted.

MINOR PLANET PREDICTIONS

Parthenope, 11, 8.6. June 26, 20:36.8 −16-48. July 6, 20:31.6 −17-30; 16, 20:24.0 −18-22; 26, 20:15.0 −19-20. August 5, 20:06.0 −20-17; 15, 19:58.3 −21-06. Date of opposition, July 25.

After the asteroid's name are its number and the magnitude expected at opposition. At 10-day intervals are given its right ascension and declination (1950.0) for 0h Universal time. In each case the motion of the asteroid is retrograde. Data are supplied by the IAU Minor Planet Center at the University of Cincinnati Observatory.

MINIMA OF ALGOL

July 1, 6:47; 4, 3:36; 7, 0:25; 9, 21:13; 12, 18:02; 15, 14:51; 18, 11:39; 21, 8:28; 24, 5:16; 27, 2:05; 29, 22:54.

August 1, 19:42; 4, 16:31; 7, 13:19.

These minima predictions for Algol are based on the formula in the 1953 *International Supplement* of the Krakow Observatory. The times given are geocentric; they can be compared directly with observed times of least brightness.

OCCULTATION PREDICTIONS

July 28-29 **Rho Sagittarii** 4.0, 19:19.2 −17-55.7, 13. Im: **E** 8:25.3 −1.4 −1.9 110; **F** 8:35.2 ... 136; **H** 7:35.9 −2.2 −0.2 85; **I** 7:32.5 −1.4 +0.3 58.

For stations in the United States and Canada, usually for stars of magnitude 5.0 or brighter, data from the *American Ephemeris* and the *British Nautical Almanac* are given here, as follows: evening-morning date, star name, magnitude, right ascension in hours and minutes, declination in degrees and minutes, moon's age in days, immersion or emersion; standard-station designation, UT, **a** and **b** quantities in minutes, position angle on the moon's limb; the same data for each standard station westward.

The **a** and **b** quantities tabulated in each case are variations of standard-station predicted times per degree of longitude and of latitude, respectively, enabling computation of fairly accurate times for one's local station (long. **Lo**, lat. **L**) within 200 or 300 miles of a standard station (long. **LoS**, lat. **LS**). Multiply **a** by the difference in longitude (**Lo−LoS**), and multiply **b** by the difference in latitude (**L−LS**), with due regard to arithmetic signs, and add both results to (or subtract from, as the case may be) the standard-station predicted time to obtain time at the local station. Then convert the Universal time to your standard time.

Longitudes and latitudes of standard stations are:

A	+72°.5,	+42°.5	**E**	+91°.0,	+40°.0
B	+73°.6,	+45°.5	**F**	+98°.0,	+31°.0
C	+77°.1,	+38°.9	**G**	Discontinued	
D	+79°.4,	+43°.7	**H**	+120°.0,	+36°.0
I	+123°.1,	+49°.5			

MOON PHASES AND DISTANCE

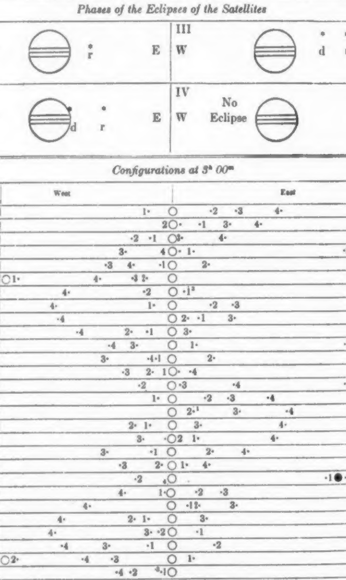
Full moon	July 1, 6:04
Last quarter	July 9, 0:21
New moon	July 16, 18:33
First quarter	July 23, 14:19
Full moon	July 30, 16:47
Last quarter	August 7, 17:49

	July	Distance	Diameter
Apogee	8, 23h	251,100 mi.	29′ 34″
Perigee	21, 11h	229,100 mi.	32′ 25″
	August		
Apogee	5, 18h	251,300 mi.	29′ 33″

JUPITER'S SATELLITES

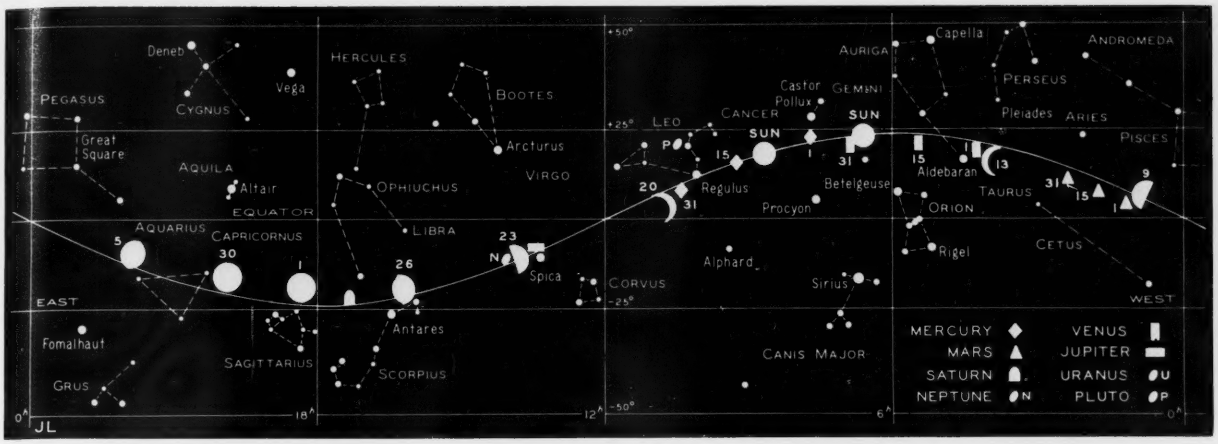
The configurations of Jupiter's four bright moons are shown below, as seen in an astronomical or inverting telescope, with north at the bottom and east at the right. In the upper part, *d* is the point of disappearance of the satellite in Jupiter's shadow; *r* is the point of reappearance.

In the lower section, the moons have the positions shown for the Universal time given. The motion of each satellite is from the dot toward the number designating it. Transits over Jupiter's disk are shown by open circles at the left, eclipses and occultations by black disks at the right. The chart is from the *American Ephemeris and Nautical Almanac*.



UNIVERSAL TIME (UT)

TIMES used in Celestial Calendar are Greenwich civil or Universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. To obtain daylight saving time subtract 4, 5, 6, or 7 hours, respectively. If necessary, add 24 hours to the UT before subtracting, in which case the result is your standard time on the day preceding the Greenwich date shown.



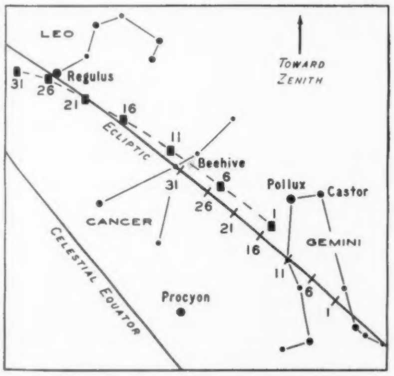
THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month or for other dates shown. All positions are for 0^h Universal time on the respective dates.

Mercury is favorably placed for viewing — an excellent summertime opportunity for those who have never identified the "elusive" planet. In mid-northern latitudes it will set an hour or more after the sun throughout the month, with greatest eastern elongation occurring on the 26th of July, 27° 06′ from the sun. The accompanying chart shows the planet's location with reference to bright stars in the western evening sky.

Early in the month Mercury will be located nearly on a line with Castor and Pollux in Gemini, but will outshine them at magnitude −0.8 on the 1st and at −0.4 on the 5th. Near the end of the month, at the time of elongation, when Mercury passes about $1\frac{1}{2}$° south of Regulus in Leo, the planet will have faded to magnitude +0.8 (as bright as Altair).

Venus on the 15th will be a brilliant −3.3-magnitude morning object in eastern Taurus, rising in the northeast about $2\frac{1}{4}$ hours before the sun. Telescopically, the planet has a gibbous disk 85-per-cent illuminated and 12″ in diameter. The moon will pass about 3° south of Venus at 6:21 UT on the morning of July 14th.



The sun's July positions (on ecliptic) and Mercury's (black rectangles) are marked on this chart, which is oriented for an observer at 40° north latitude, looking westward at about sunset.

Earth is at aphelion on the 5th, $94\frac{1}{2}$ million miles from the sun.

Mars comes to western (evening) quadrature with the sun on the 27th, rising about $\frac{3}{4}$ hour before midnight, local time. On that date it will be a zero-magnitude object near the point where Pisces, Aries, and Cetus meet, and in a telescope will have a disk 10″ in diameter. The moon will be about 3° north of Mars on the morning of the 9th.

Jupiter is in Virgo, visible in the western sky during the evening. It reaches eastern quadrature on July 15th, then setting about half an hour before midnight, local time. It is of apparent magnitude −1.6, brighter than Sirius. There will be a conjunction of Jupiter and the moon on the evening of the 22nd, with the planet $1\frac{1}{2}$° north as seen from the center of the earth.

Saturn is in Ophiuchus during July, and on the 15th crosses the meridian near 9:30 p.m., local time. The moon will be in conjunction with Saturn on the 27th. The orbits of the planet's satellites were charted on page 409 of the June issue.

Uranus is in Cancer, too close to the sun to be seen, setting before evening twilight ends.

Neptune will remain nearly unchanged in position all month, in Virgo about 8° east of Jupiter. On the 25th, Neptune will reach eastern quadrature, at right ascension 14^h $01^m.9$, declination −10° 32′ (1958 co-ordinates). It is visible in good binoculars, but a fairly large telescope is required to show clearly its tiny disk, only 2″.4 in diameter at this time.

Artificial satellite observations during the period of dusk may be made with the aid of the star chart in this issue. For morning work use the chart from an October number for the early part of July, from a November issue for the latter part.

W. H. G.

JULY METEORS

The moon, full on July 30th this year, will severely hamper observations of the Delta Aquarid meteor shower. Maximum will occur on July 29th, but some members of the shower may be seen about a week before and after that date. The radiant will be at right ascension 22^h 36^m, declination −17° at the height of the shower, when under favorable conditions in past years individual watchers have recorded 20 meteors an hour after midnight.

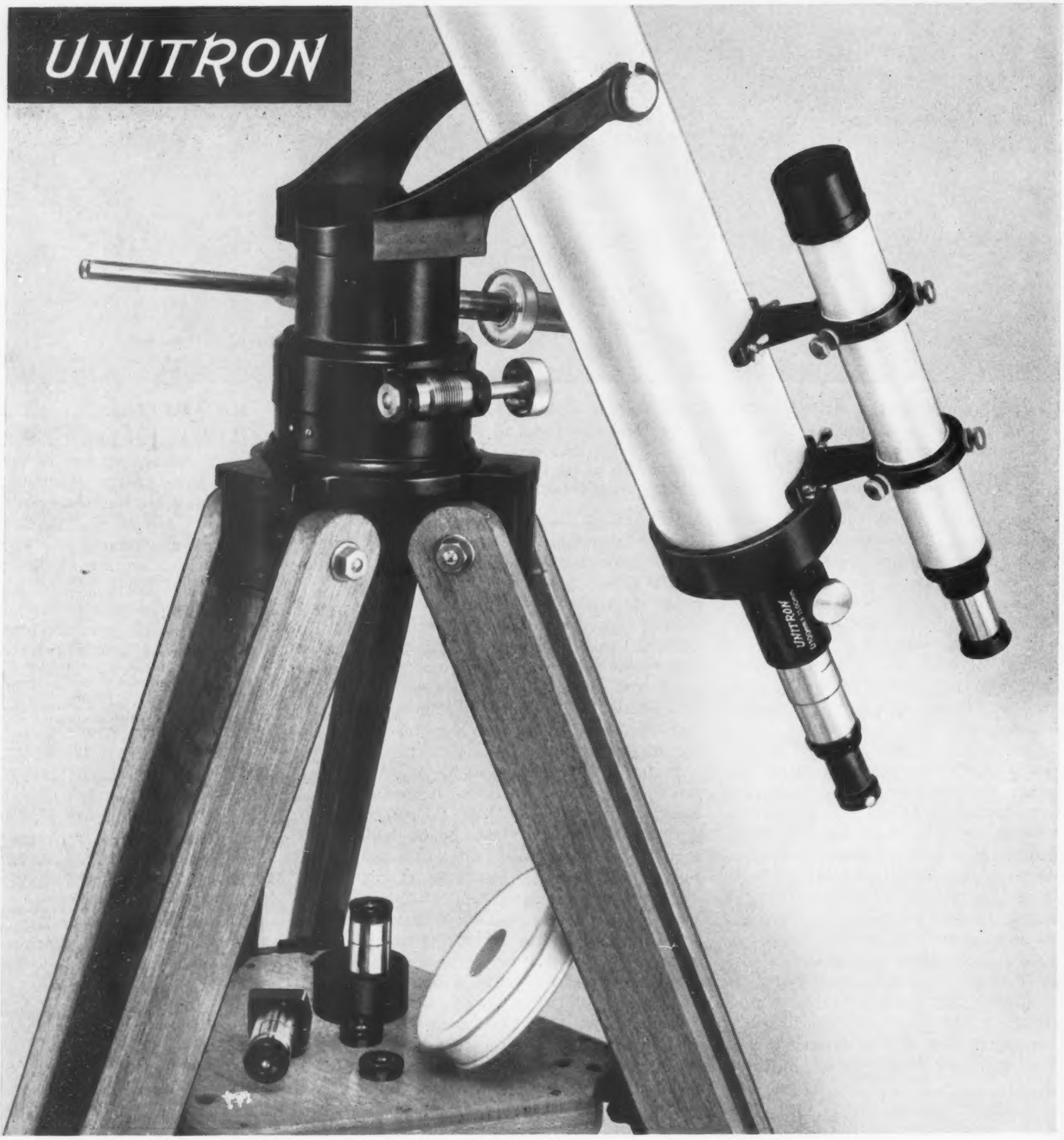
W. H. G.

VARIABLE STAR MAXIMA

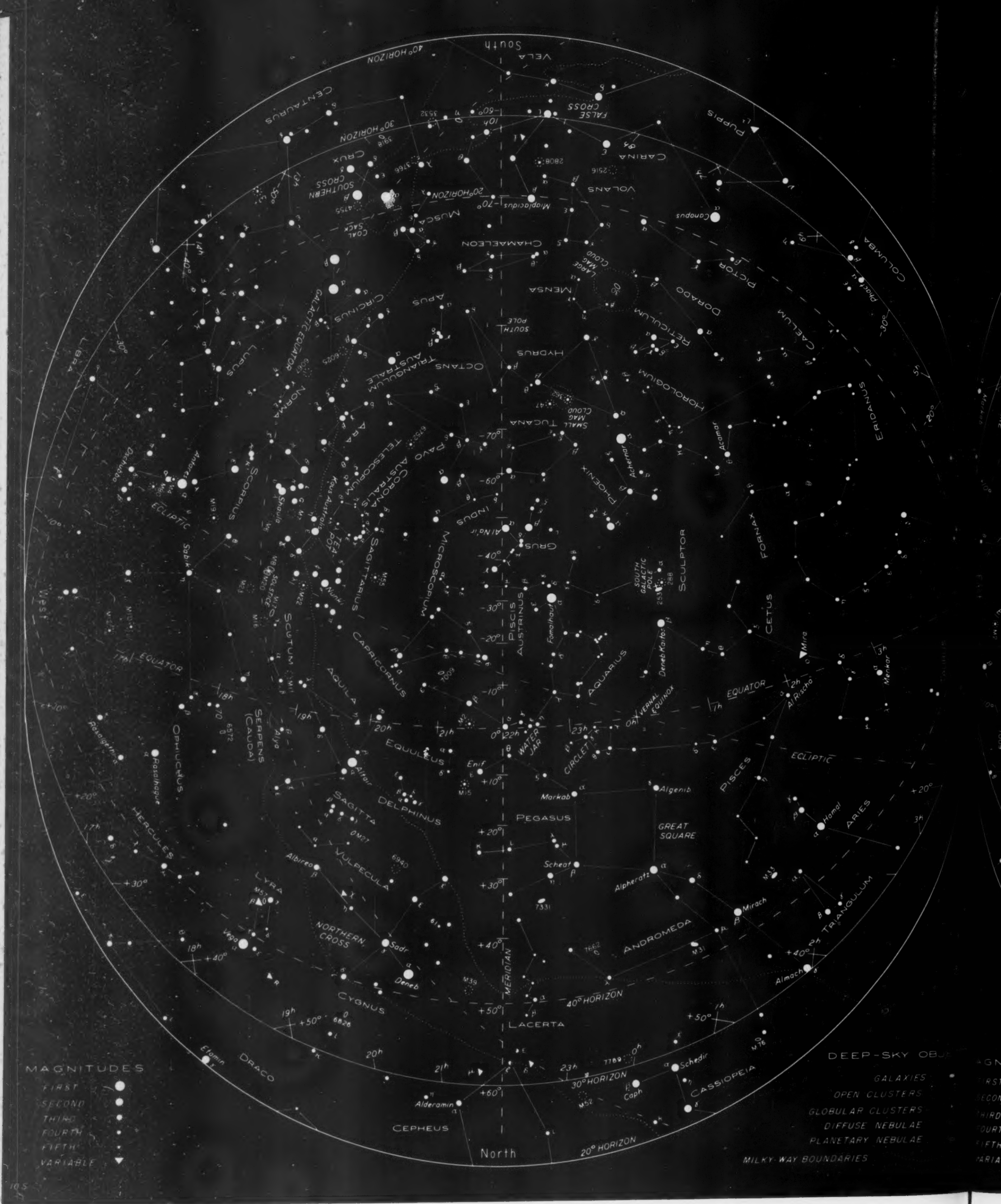
July 5, T Herculis, 180531, 8.0; 6, RT Cygni, 194048, 7.4; 8, W Lyrae, 181136, 8.0; 17, R Corvi, 121**418**, 7.6; 17, V Cancri, 081617, 8.0; 23, R Trianguli, 023133, 6.3; 24, R Leonis, 094211, 5.9; 24, T Normae, 153**654**, 7.4; 26, R Reticuli, 043**263**, 7.7; 28, R Ophiuchi, 170**215**, 7.6; 28, SS Virginis, 122001, 6.9.

August 2, S Virginis, 132**706**, 7.1; 4, U Herculis, 162119, 7.6; 7, R Carinae, 092**962**, 4.6; 10, R Draconis, 163266, 7.6.

These predictions of variable star maxima are by the AAVSO. Only stars are included whose mean maximum magnitudes are brighter than magnitude 8.0. Some, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for maximum. The data given include, in order, the day of the month near which the maximum should occur, the star name, the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern), and the predicted magnitude.



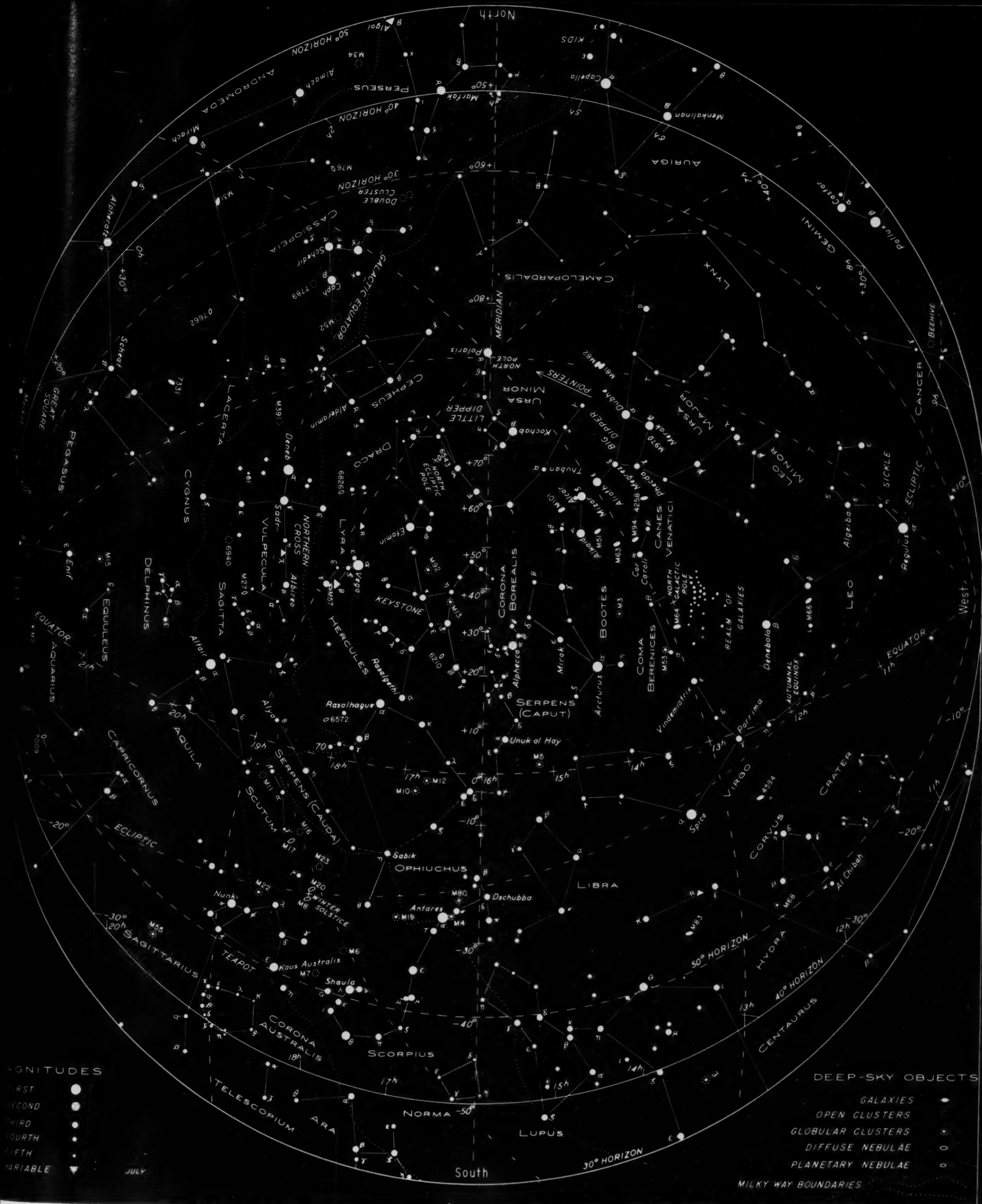
See the back cover.



SOUTHERN STARS

The sky as seen from latitudes 20° to 40° south, at 11 p.m. and 10 p.m., local time, on the 7th and 23rd of September, respectively; also, at 9 p.m. and 8 p.m. on October 7th and 23rd. For other dates, add or subtract ½ hour per week.

Watery constellations draw attention at this time. Aquarius and its Water Jar are high, and Capricornus, the Sea Goat, is near the meridian also. Piscis Austrinus, the Southern Fish, can be easily identified by 1st-magnitude Fomalhaut; Delphinus is near the Milky Way.



STARS FOR JULY

The sky as seen from latitudes 30° to 50° north, at 9 p.m. and 8 p.m., local time, on the 7th and 23rd of July, respectively; also, at 7 p.m. on August 7th. For other dates, add or subtract ½ hour per week.

Scorpius nears the meridian at chart time, and dominates the southern sky during early summer. Serpens and Corona Borealis (the Northern Crown) are higher in the sky, and Hercules is favorably placed nearby. The Milky Way stretches across the eastern sky from north to south.

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